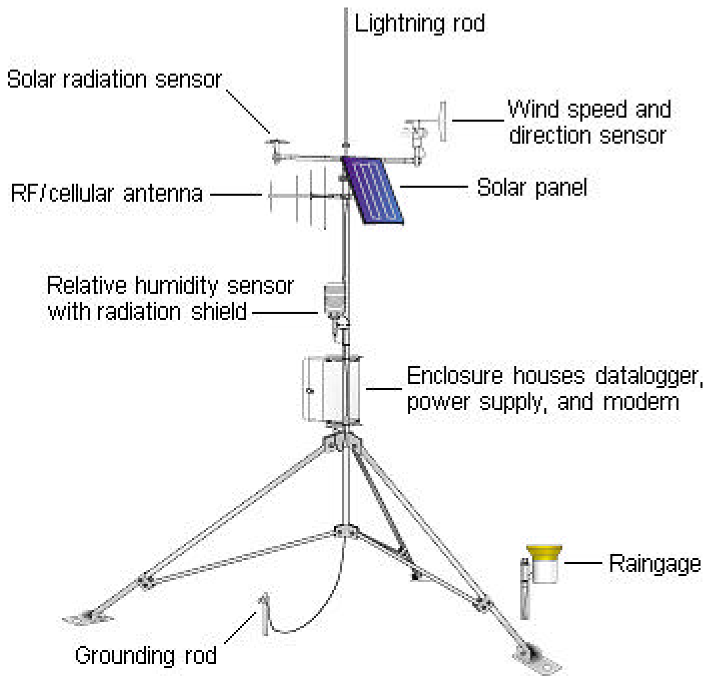
Weather Monitoring Protocol for Two Prairie Parks

Northern Prairie Wildlife Research Center Inventory and Monitoring Protocol



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Weather Monitoring Protocol for Two Prairie Parks

By

F. Adnan Akyüz, Ph.D., and Patrick Guinan
Missouri Climate Center
University of Missouri-Columbia
100 Gentry Hall
Columbia, Missouri 65211

And

Gary D. Willson, Ph.D.
U. S. Geological Survey
Northern Prairie Wildlife Research Center
Biological Resources Division
University of Missouri-Columbia
200 Gentry Hall
Columbia, Missouri 65211

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1.0 INTRODUCTION

1.1 Background

Accurate weather and climate data are important tools used by natural resources managers in planning and decision-making (e.g., weather prescriptions in fire management). Under the National Park Service Inventory and Monitoring Program, minimal data sets for parks include precipitation and other weather variables. As part of the national program, the Prairie Cluster Long-Term Ecological Monitoring (LTEM) Program will focus on monitoring terrestrial plant communities and rare plant populations in small national parks in mid-continent areas. Weather and climate affect the structure and function, including biomass production, species composition, and diversity, of grassland ecosystems. Therefore, continuous weather monitoring is a key factor in separating the effects of climate from the effects of management actions on plant community and population dynamics in prairie parks. Although the protocol was developed to monitor weather at Pipestone National Monument (PIPE) in Minnesota and Wilson's Creek National Battlefield (WICR) in Missouri, it can, with minor modification, be used at other parks with similar weather monitoring objectives and instrumentation.

1.2 Objectives of weather monitoring

The objectives of the weather monitoring protocol are to provide park managers and cooperators with 1) park-specific monthly and annual climate summaries, 2) habitat-specific climate data relevant to predicting population dynamics of two federally listed rare plant species, 3) year-to-year variation in plant communities in relation to yearly climate fluctuations, and 4) input data for National Fire Danger Rating System (NFDRS) fire weather indices calculations.

2.0 MONITORING PROTOCOL

2.1 Weather station locations

On June 19, 1995, an automated weather station was installed on North Bloody Hill Glade at WICR. On June 19, 1995, a second station was installed adjacent to Management Unit 2 at PIPE (Figure 1). The primary factor in determining locations of these stations was proximity to habitat of the endangered Missouri bladderpod at WICR and the threatened western prairie fringed orchid at PIPE. World Meteorological Organization (WMO) (1969) criteria for locating weather stations were followed as closely as possible. However, at WICR, small trees are located within the 300-m zone that the WMO recommends be free of obstructions. At PIPE the resources manager's office at PIPE is also situated within the 300-m zone in the direction opposite the prevailing wind direction.

2.2 Weather station specifications

Weather stations currently in use at PIPE and WICR are Campbell Scientific, Inc., Model CM10 field stations (Figure 2). These stations are self-contained instrument packages used to automatically record, store, and communicate weather and climate data from remote sites. Due to their remote locations, a solar panel and battery provide power to each station. Table 1 describes the locations of the weather stations at WICR and PIPE including elevation, longitude, and latitude.

The stations consist of galvanized steel, 3-m tripods that support the solar panel, weather sensors (except rain gauge and soil temperature/moisture sensors), antenna (WICR only), and a weatherproof enclosure that houses the datalogger, battery, modem, and transmitter (WICR only). Each station is connected to a grounding rod by copper wire. The grounding kit consists of a lightning rod mounted at the top of the mast and connected to the grounding wires of the datalogger and sensors. Copper wire connects the lightning rod to a copper grounding rod that is driven into the earth. Sensors common to both stations include a cup anemometer and wind vane, temperature and relative humidity sensors, pyranometer, tipping bucket rain gauge (heated at PIPE), soil temperature and soil moisture sensors, and fuel moisture sensors. In addition, at WICR the weather station includes a snow-depth sensor. Location of the sensors on the tripod follows standard WMO guidelines (1969), except for the cup anemometer. The National Weather Service (NWS) officially records wind measurements at 10 m above ground. At PIPE and WICR, the cup anemometer heights are constrained by the height of the CM10 station, which is 2 m above the ground, but wind measurements can be adjusted for the reference height of 10 m (Akyüz 1996).

At PIPE and WICR, to minimize interference, the rain gauge is located at a distance twice the height of the nearest obstruction. At WICR, soil moisture and soil temperature sensors are deployed within 20 m of the tripod to record differences in microclimate in glade microhabitats described by Thomas (1996). At PIPE, soil moisture and soil temperature sensors are deployed at 2 locations within clusters of western prairie fringed orchids to capture potential differences between the core orchid population and marginal habitat at the population edge. Table 2 gives the distance from the weather station and depth below ground of the moisture and temperature sensors at PIPE and WICR. The specifications for weather station sensors and communication equipment are provided in Appendix A.

2.3 Weather station data acquisition and storage

A datalogger (Campbell Scientific CR10X) is located within the weatherproof enclosure of the weather station. The datalogger consists of a measurement and control module and an attached wiring panel. The measurement and control module is programmable and provides sensor measurement, timekeeping, communication, data reduction, data program storage, and control functions. The wiring panel includes screw terminals for sensor connections and a 9-pin serial input/output port. The datalogger is programmed to read data from the sensors at 60-second intervals. Numerically, 62,280 data points, approximately 10 weeks of data for PIPE and eight weeks for WICR, can be stored in memory. By means of telecommunication peripherals (PIPE – telephone line, WICR – cellular telephone), the datalogger allows interrogation from a remote computer.

2.4 Base station operation

Technical support for weather station operations and data archiving is provided by the Missouri Climate Center, which is located within the Department of Soil and Atmospheric Sciences at the University of Missouri-Columbia. Under a cooperative agreement between the National Park Service (FIREPRO) and the University, the state climatologist with training in automated weather station operation serves as data administrator and equipment technician. He is responsible for weather station data acquisition, data quality control and archiving, and data analysis and reporting as well as equipment maintenance and instrument calibration. A computer located in the Climate Center is used for short-term storage of the weather data (see Section 2.11 for a description of long-term data archiving.) Data are formatted in comma-delineated ASCII files. Personnel at the individual parks may also access real-time and stored weather data by modem connection to the weather stations without disrupting data assimilation and archiving by the state climatologist at the Climate Center.

2.5 PC208W

A Campbell Scientific, Inc., software program, PC208W, (Campbell Scientific, Inc. 1997), provides computer/datalogger communication for data collection and real-time data display. In addition, it provides tools for setting the datalogger clock, transferring datalogger programs, and testing communication links. PC208W can also be used as a starting point to access related software programs.

2.5.1 *PC208W overview* - In a Microsoft Windows environment, the PC208W menu bar will appear when the PC208W button is double-clicked. This toolbar has eight buttons with the following functions:

- Setup: Describes the configuration of COM ports, modems, dataloggers, and other devices; sets up the data collection protocols and schedules. Appendix F shows the setup configuration for WICR and PIPE.

- Connect: Connects to each automated weather station configured in the "setup" option; synchronizes datalogger clock with the computer's clock; collects data and downloads **.dld** files to dataloggers from a PC; views collected data and graphs real-time measurements.

- Status: Checks the communication and data collection status of all stations in the network; shows station names, whether or not a specific station is on line, error rates, time and date when the last data collection was attempted, how much data was collected, and the next call schedule.

- Program: Creates and edits datalogger programs for the CR10(X). Appendices G and H are the edlog programs that are executed by the dataloggers at WICR and PIPE, respectively.

- Report: Runs SPLIT (processes the data files and creates reports). Appendices I and J show the input and output variables run by SPLIT for WICR and PIPE, respectively.

- View: Depicts visually the collected data file in either ASCII or HEX formats, up to the date/time when the data was last collected.

- Stg Module: Retrieves files from storage modules via either a CR10(X) and PC-cards or the CSMI/MCRI interface or directly from a PCMCIA slot in the computer with separate tab settings for the categories "setup", "programs", "data" and "erase."

- Help: Launches the PC208W "Help" system with easy-to-follow instructions. To obtain help on a specific feature, simply click on that feature's button on the toolbar while the help file is running.

2.6 Weatherpro program capabilities and functions

Weatherpro software (Remsoft 1996) acts as a core program that supports add-on modules and user-defined features. It is used to collect data in automatic or user-initiated mode from a Campbell Scientific, Inc. (CSI) automated weather station for upload to WIMS. It does not provide for real-time monitoring of weather data.

2.6.1 *Weatherpro overview* - Weatherpro is a DOS program that may be launched by typing "wxp" when prompted. The following describes the menu items that will appear on the screen.

- Collect Weather Data: Collects weather data on schedule or manually from the selected CSI weather station.

- Edit Weather Data: Provides options for manual data entry, data modifications, and forecast entry.

•	Output Weather Data:	Enables data printing, WIMS transmission, and file transport options.
•	Graph Weather Data:	Graphs the output data.
•	Setup & Configuration:	Includes all the tasks related to weather station options, station group options, equations and tables, and computer configurations. This should be completed first.

2.6.2 *Add-on modules*

2.6.2.1 Campbell Scientific, Inc. (CSI) link module

The CSI link is a standard module for the Weatherpro software. Therefore, installation of this link occurs automatically when the Weatherpro software is installed. Furthermore, because the CSI link is background operational software its operation is opaque to users when communication is established. The CSI link is used as a bridge to read data records collected by CSI's automated weather stations and to store the values in Weatherpro data files. Once the data are stored, fire weather input data or other calculations can be carried out within the Weatherpro environment.

2.6.2.2 WIMS module

Weather Information Management Systems (WIMS) is a comprehensive system hosting the National Fire Danger Rating System (NFDRS). WIMS was established in 1992 and is maintained by the USDA National Computer Center (NCC) in Kansas City, Missouri. It provides users in the Forest Service and other land management agencies access to multiple weather information throughout the United States, tools for data management and display, and an interactive platform to access and manipulate weather data.

Prior to using WIMS, a logon identification number must be established through the NCC. As part of their security procedures, NCC security personnel recommend that the logon ID be changed every 30 days. If a logon ID is not used for 90 consecutive days, it will be deactivated. Once an ID number has been obtained and connection to WIMS is established, the WIMS module uploads fire weather input data automatically. The data can then be used to calculate NFDRS fire codes, such as Burning Index (BI), Ignition Component (IC), Energy Release Component (ERC), Spread Component (SC), etc. for weather station sites. BI, IC, ERC, and SC are the main components of the NFDRS structure (Andrews and Bradshaw 1992).

The WIMS output (fire codes) data can be retrieved for a selected station via the Internet using the following URL: http://fire.nifc.nps.gov/webterm/wims.asp. An authorization number is required to log in. To prevent unauthorized access, a user representative assigns each user a separate authorization number. Figures 3 and 4 are samples of NFDRS output for PIPE and WICR, respectively, from December 20, 1998.

2.7 WIMS upload

Weatherpro uploads 17 standard fire weather fields separated by commas to WIMS by default. An additional 9 fields (4 soil moisture, 4 soil temperature, and 1 solar radiation) from WICR and 5 fields (2 soil moisture, 2 soil temperature, and 1 solar radiation) from PIPE are uploaded by default. If records are missing from the file, they are uploaded as an asterisk (*). Thus, their corresponding output value(s) will not be calculated. However, missing values may be edited later by logging onto WIMS via the above Internet address. It is also important to update information in the "Station Catalog," one of the menu items in WIMS, whenever a change occurs. This information cannot be updated automatically during a daily automated upload procedure, but it should be edited by park personnel at the site. There are also three other fields in the default WIMS upload procedure that require editing at the site daily, after the automatic upload is completed, because these cannot be automated. These fields are: state of weather, man-caused risk, and lightning activity level. Table 3 shows the input variables, input frequency, and the staff person responsible. WIMS station IDs for each station, as well as other configurations, are shown in Table 1 and Figures 3 and 4. More detailed information about the topics mentioned above may be acquired from the WIMS "User's Guide" (USDA 1997).

2.8 Communication

The weather stations at WICR and PIPE continuously collect and store weather data 24 hours a day. This information is retrievable via antenna and cellular telephone package at WICR and telephone line connected to a modem at PIPE. Southwestern Bell is the service provider for the cellular line, 573-999-0359, at WICR, and Northwestern Bell is the local provider for the line 507-826-2669 at PIPE. It takes less than 1 minute for daily information to be downloaded from each station. It takes longer to download information for periods longer than one day.

2.8.1 *Real-time monitoring* - While PC208W is running, real-time monitoring may be activated by first accessing the desired station, then launching the "Numerical Display" window. Data shown in the "Numerical Display" window are updated every minute. A table, including Input Location Labels and real-time values, appears on the screen as shown in Table 4. A complete list of input locations is given in the last pages of Appendices G and H, which are EDLOG programs for WICR and PIPE.

2.8.2 *Data collection* - PC208W will collect all data stored in the weather station datalogger since the last retrieval of data (the program keeps track of where it leaves off after each data collection.) Data collected is automatically appended to the file **wcreek.dat** or **pstone.dat**. That is, the data file consists of the same name as the station name with a **.dat** extension. These data are stored in the **.dat** file in the format selected in the station file, comma-delineated ASCII or binary (same as in the datalogger).

Definitions of the array structure are given in Appendices K and L for WICR and PIPE respectively. The Missouri Climate Center base station computer automatically collects and archives data daily from the weather stations. Automated data collection with Weatherpro is also scheduled daily for fire weather input data to be uploaded to WIMS.

2.9 Data management

2.9.1 *SPLIT overview* - SPLIT is a general purpose data reduction program. Input files are accessed by SPLIT, specific operations are performed on the data, and the results are output to file. When SPLIT is loaded, a list of prompts/questions is brought to the screen. When answered, these prompts define what files are accessed, what operations are performed, and to what file the results are output. The completed set of prompts with instructions may be saved as a parameter file (e.g., wcreek.par, pstone.par). The parameter file may be called into SPLIT for future use. Appendices I and J show parameter files for WICR and PIPE, respectively.

SPLIT applications include: data processing, file reformatting, data quality checking (limit testing), table generation with report and column headings, time synchronization and merging of up to eight files, and data selection based on time or conditions. The output displayed on the screen provides immediate feedback as to the effect of changes or new entries to the parameter file. The input file, however, is not affected by SPLIT.

2.9.2 *SPLIT activation* - SPLIT can be run from the PC208W toolbar by clicking on the Report button in the PC208W program.

2.10 Data quality control

SPLIT will be used to identify data problems. Range limits (lower to upper boundary conditions) are placed on elements or groups of elements specified in the SELECT box. The range limits for WICR and PIPE are delineated in Table 5. Climatological and geographical locations of the weather stations were considered when the range limits were set. The state climatologist will check data quality on a daily schedule. This way, any problems related to hardware, software, and raw data can be discovered within a 24-hour period except on weekends and holidays. The quality of data uploaded to WIMS is checked within the system.

2.11 Data archive

The state climatologist archives daily and hourly weather data in the Missouri Climate Center in high resolution (1-min) to a ZIP drive for long-term storage. The raw data initially is downloaded in comma-separated ASCII format, the format in which the datalogger stores the data in the final storage area. Once the data is downloaded, the SPLIT program automatically creates daily reports to be uploaded to the Midwestern Climate Center's computer server. In addition, the dedicated Fire Weather computer automatically uploads the hourly information to WIMS once a day for archiving. WIMS will archive the hourly data on active service for 18 months and on tapes thereafter.

Table 8 shows the data archiving acquisition in detail, and Table 9 shows the data access system.

2.12 Reports

The state climatologist will provide daily (upon request) and monthly weather summaries to park managers at WICR and PIPE. Table 6 gives an example of a daily weather summary, and Appendix B is an example of a monthly status report. The state climatologist will provide hourly fuel moisture averages with the daily weather summary, although it is anticipated that real-time monitoring of fuel moisture will be of greater value to park managers. The state climatologist will also provide an annual report of weather, including monthly means. Appendix C is an example of an annual report. Monthly reports are to be made within 5 days after the proceeding month, whereas annual reports will be made in January after the proceeding year. Copies of all reports will be forwarded to the Prairie Cluster LTEM Program office at WICR. Reports are also posted on the Missouri Field Station LTEM web site on a monthly basis: for WICR, http://www.missouri.edu/~aggwills/wilsons/monit/meteo/ and for PIPE, http://www.missouri.edu/~aggwills/pipe/monit/meteo/. The sites include an e-mail link that allows visitors to request additional information.

2.13 Weather station maintenance

Proper maintenance of the weather station components is essential to obtain accurate data. Equipment must be in good operating condition; this requires a program of regularly scheduled inspections and maintenance. Most maintenance procedures, such as sensor calibration, sensor performance testing, and sensor component replacement, typically require a skilled technician and will be done by the state climatologist.

The state climatologist will keep a station maintenance log for each weather station. Included in this log will be the manufacturer's serial number for weather station components, dates that the site was visited, dates station inspections were performed, and, if maintenance was done, specifically what type. A sample maintenance log sheet is found in Appendix D, and a schedule of maintenance and equipment needed is found in Appendix E. During scheduled weather station maintenance, the state climatologist will complete the RAWS maintenance narrative (see form in Appendix D).

3.0 INTEGRATION

On-site weather data may be used to explain changes in plant and animal populations and communities. It may also be used to develop and test hypothetical models of how weather affects plants and animals directly, or, for example, through interactions among prescribed fire, plant habitat response, and weather. Table 7 shows the climate variable that will be tested for significant correlations with population changes in the Missouri bladderpod and western prairie fringed orchid once weather and plant population data sets of at least 10 years are compiled. Multiple regression techniques or principal component analysis will be used to determine the most predictive climate model.

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Table 1. Weather station locations at Wilson's Creek National Battlefield and Pipestone National Monument.

Park	Station name (#)	Location	Elevation	Longitude	Latitude
WICR	Wilson's Creek (237001)	North Bloody Hill Glade	364 meters	93E 24.60W	37E 06.59N
PIPE	Redstn (21690)	Management Unit 2	536 meters	96E 19.29W	44E 00.59N

Table 2. Soil moisture and temperature sensor locations at Wilson's Creek National Battlefield and Pipestone National Monument.

Station	Microhabitat	Distance from the station (m)	Depth below ground (cm)
WICR	Rocky Habitat	4.62	4
	Mixed Habitat	7.62	4
	Warm Season Grass Habitat	7.62	4
	Shaded Habitat	15.20	4
PIPE	CORE	30.50	9
	EDGE	95.50	9

Table 3. Input variable and frequency for WIMS upload and responsible staff/cooperator.

Input Variable	Input Frequency		
Station catalog	Initially	Seasonally	Daily
Station ID	RM		
Evaluation	RM		
Latitude	RM		
Longitude	RM		
Lightning scaling factor	RM		
Avg. annual precipitation	M		
Slope aspect	RM		
Humidity code	M		
Rainfall code	M		
Temperature code	M		
Wind speed code	M		
NFDRS parameters			
Model ID		RM	
(HS) Herbaceous vegetation stage code		RM	
HS date		RM	
Greenup date		RM	
(Sb) Shrub cover	RM		
(Slp) Average slope	RM		
(Grs) Grass code	RM		
(Cli) Climate	M		
Greenness factor		RM	
Automated [1]			
Year			M
(T) Temperature			M
(RH) Relative humidity			M
(WD) Wind direction			M
(WS) Wind speed			M
1-hr rainfall			M
(FSM) Fuel moisture			M
(FST) Fuel temperature [2]			M
24-hr rainfall duration			M
24-hr total rainfall			M
24-hr max-T			M
24-hr min-T			M
24-hr max RH			M
24-hr min RH			M
Manual [3]			
State of Weather [4]			RM
Man-caused Risk			RM
Lightning Activity Level			RM

Table 3 footnotes:

RM - Resource Manager
M - Meteorologist

[1] - The meteorologist will monitor all automated entries.

[2] - PIPE does not currently have a fuel temperature sensor. Because Weatherpro must send this information by default, the variable field will automatically be input as an asterisk (*).

[3] - These input variables are automatically input as asterisks (*) by default. The resource manager at the site should manually enter these variables.

[4] - Development of a script program to automate the State of Weather is underway. Once it has been completed and implemented, WIMS upload could be fully automated provided that Man-caused Risk and Lightning Activity Level variables could be set to initial values, until they change.

Table 4. Input location labels.

Number:Description	Value
1:BattVolt	13.5
2:TempC	25.1
3:RH%	58.4
4:Wspdm/s	0.914
5:Wdirdeg	12.8
6:slrW/m^2	678
7:Rainmm	0
8:300stempc	21.0
9:200stempc	21.8
10:100SM	0.14
11:300SM	0.09

Table 5. Weather variable range limits for Wilson's Creek National Battlefield (WICR) and Pipestone National Monument (PIPE).

Variable	WICR	PIPE
Temperature	-35 # X # 50E C	-40 # X # 60E C
Relative Humidity	10 # X # 100%	10 # X # 100%
Wind Speed	0 < X # 60 m/s	0 < X # 60 m/s
Wind Direction	0 < X < 360E	0 < X < 360E
Precipitation	0 # X # 102 mm	0 # X # 76 mm
Solar Radiation	0 < X < 1100 w/m^2	0 < X < 1000 w/m^2
Soil Temperature	-35 # X # 50E C	-35 # X # 50E C
Soil Moisture	0 < X < 65%	0 < X < 65%
Snow Depth	0 # X # .76 m	N/A
Fuel Moisture	5 # X # 55%	5 # X # 55%

Table 6. Pipestone National Monument daily weather summary for October 22, 1995.

DAY	**HOUR**	**AVG AIR TEMP** (°F)	**PRECIP** (in)	**AVG WIND SPEED** (mph)	**VECTORAL MEAN WIND DIRECTION** (deg)	**AVG RAD** (w/m^2)	**AVG REL HUM** (%)	**FUEL MOIS** (%)
10 22	0100	29.1	0.00	1.7	86.30	0.0	88.0	13.8
10 22	0200	27.5	0.00	1.6	125.00	0.0	86.5	14.0
10 22	0300	26.4	0.00	2.0	100.40	0.0	89.4	18.4
10 22	0400	27.9	0.00	3.4	97.50	0.0	86.7	14.2
10 22	0500	27.0	0.00	1.4	101.30	0.0	91.1	14.4
10 22	0600	25.6	0.00	0.6	127.80	0.0	93.7	25.6
10 22	0700	26.6	0.00	0.9	75.60	3.1	93.2	15.9
10 22	0800	31.3	0.00	2.2	84.60	66.7	84.8	16.7
10 22	0900	37.1	0.00	5.8	56.45	130.8	82.5	21.1
10 22	1000	38.3	0.00	4.2	58.75	200.0	79.2	14.6
10 22	1100	39.4	0.00	6.0	47.21	395.2	68.0	15.4
10 22	1200	39.7	0.00	6.7	50.89	367.2	71.8	14.6
10 22	1300	38.2	0.00	5.1	63.17	210.4	78.9	17.9
10 22	1400	38.0	0.00	6.9	47.76	256.1	77.7	15.0
10 22	1500	39.3	0.00	8.0	39.62	421.6	79.9	18.6
10 22	1600	35.9	0.00	9.1	28.42	120.3	90.5	25.4
10 22	1700	35.6	0.00	9.5	21.37	44.1	86.8	17.1
10 22	1800	36.2	0.00	8.4	27.54	5.5	88.8	13.4
10 22	1900	37.2	0.00	8.2	23.96	0.0	85.3	13.6
10 22	2000	38.1	0.00	8.4	30.88	0.0	83.9	13.6
10 22	2100	38.6	0.00	9.3	33.16	0.0	82.4	25.4
10 22	2200	39.0	0.00	11.1	40.16	0.0	81.7	13.8
10 22	2300	39.1	0.00	11.0	44.23	0.0	80.2	13.8
10 22	2400	39.8	0.00	10.8	43.97	0.0	77.6	26.7

Table 7. Climate variables being tested for correlations with rare plant population sizes.

Climate variable	**Rare plant**	
	Western prairie fringed orchid	Missouri bladderpod
No. days > 35E C		X
No. days with snow cover		X
No. of freeze/thaw cycles		X
No. of days soil temperature < 32EC		X
Degree days (DD) in August		X
Degree days (DD) in September		X
March precipitation index [1]	X	X
April precipitation index	X	X
May precipitation index	X	X
June precipitation index	X	
July precipitation index	X	
August precipitation index	X	
September precipitation index	X	X
October precipitation index		X
November precipitation index		X
Spring precipitation index	X	X
Fall precipitation index	X	X

[1] Index is calculated as the actual precipitation on site divided by the normal precipitation reported from the nearest National Weather Service Reporting Station.

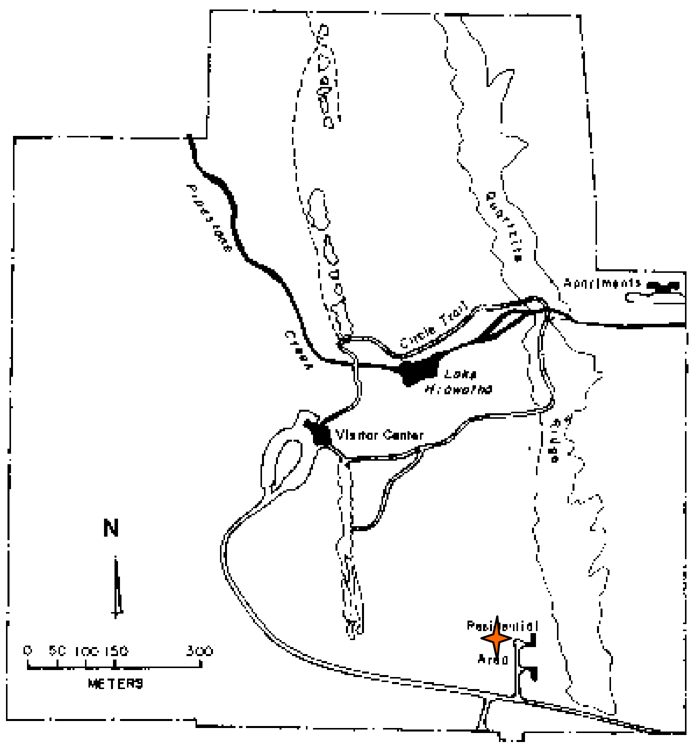
Table 8. Data archiving acquisition.

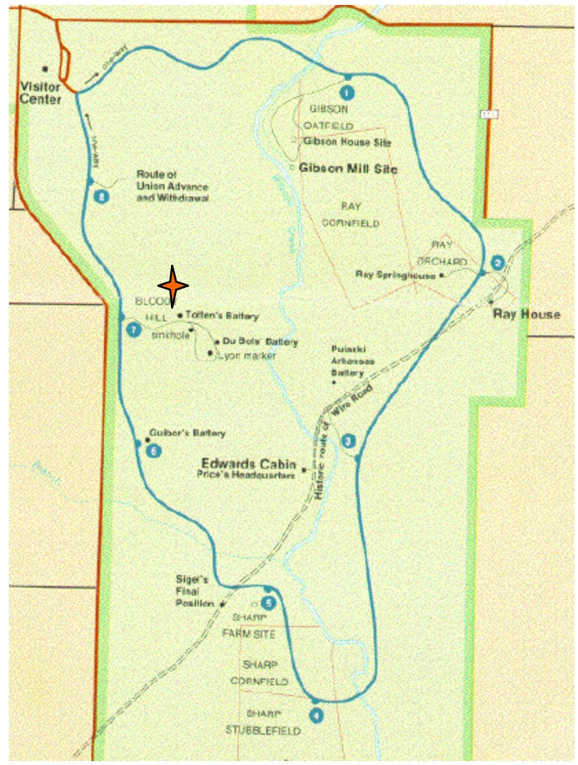
Archived location	Data format	Data resolution	Archiving frequency
Missouri Climate Center	ASCII HTML Tabular Hard copy Text	Hourly Daily Monthly	Daily
Midwestern Climate Center	Tabular Text	Hourly	Daily
WIMS	ASCII	Hourly	Daily
WICR	Hard copy "Report"	Daily Monthly	Monthly Annually
PIPE	Hard copy "Report"	Daily Monthly	Monthly Annually

Table 9. Data access system.

Data	Method	Who can access
Real time	PCZO8W Software Section 2.8.1	Resources Managers at WICR and PIPE The state climatologist
Daily reports	Midwestern Climate Center www.sws.uiuc.edu	Anyone
Monthly reports	Missouri Climate Center www.missouri.edu/~moclimat PIPE WICR	Anyone
Annual reports	Missouri Climate Center www.missouri.edu/~moclimat PIPE WICR	Anyone
Raw data	Missouri Climate Center	Anyone upon request

Pipestone National Monument **Wilson's Creek National Battlefield**





Weather Station Locations

Figure 1. Map of automated weather station locations at Wilson's Creek National Battlefield and Pipestone National Monument.

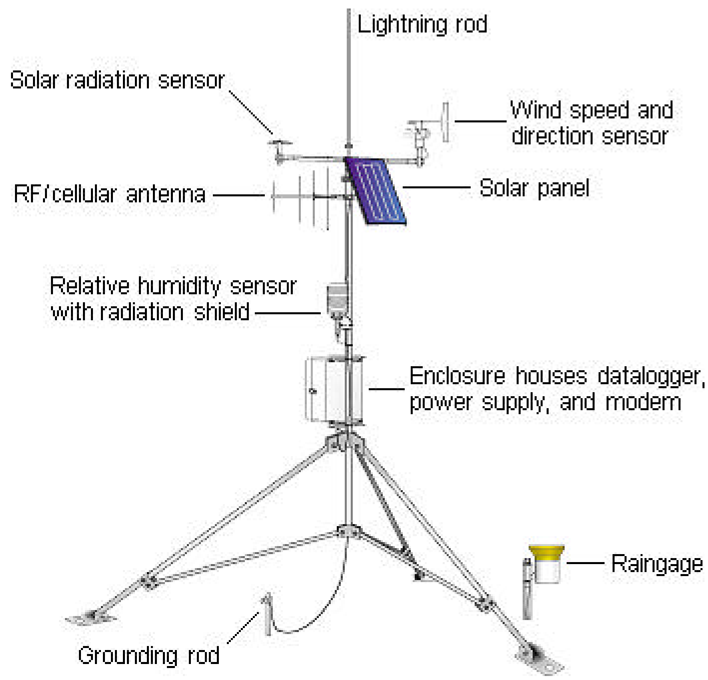
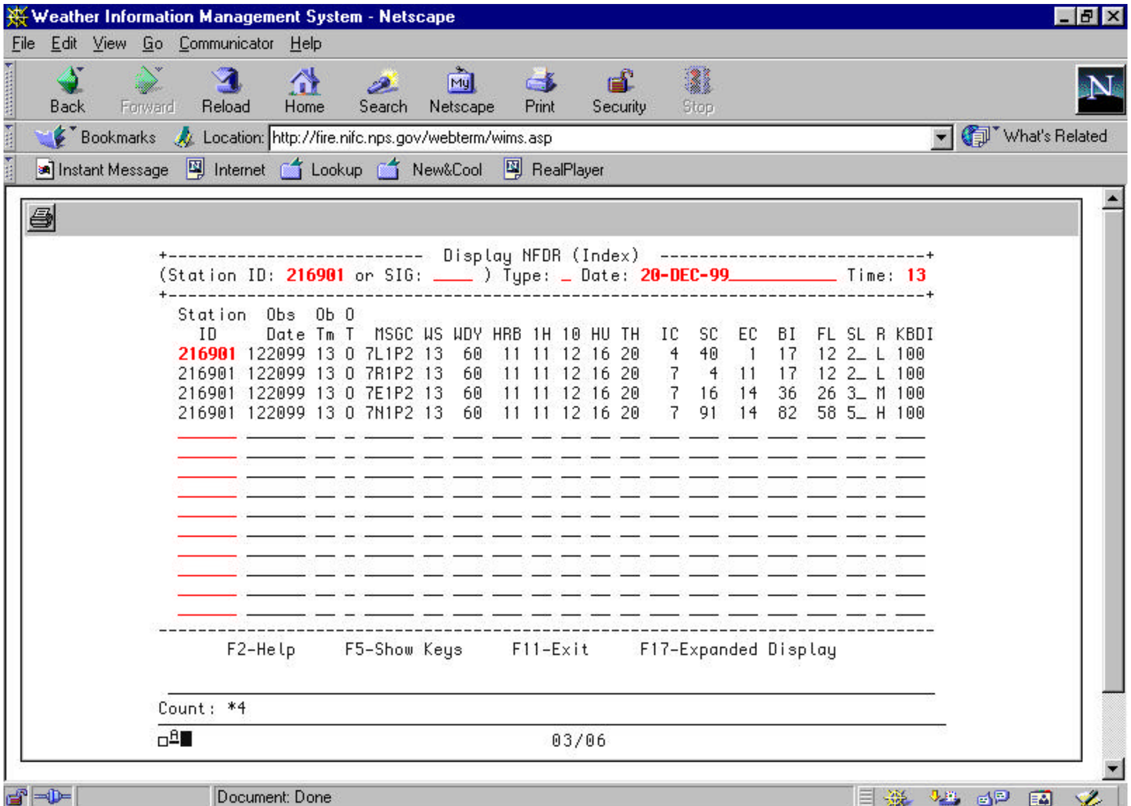


Figure 2. Side view of the Model CM10 automated weather station.


Weather Information Management System - Netscape

Location: http://fire.nifc.nps.gov/webterm/wims.asp

Display NFDR (Index)

(Station ID: 216901 or SIG: ____) Type: _ Date: 20-DEC-99________ Time: 13

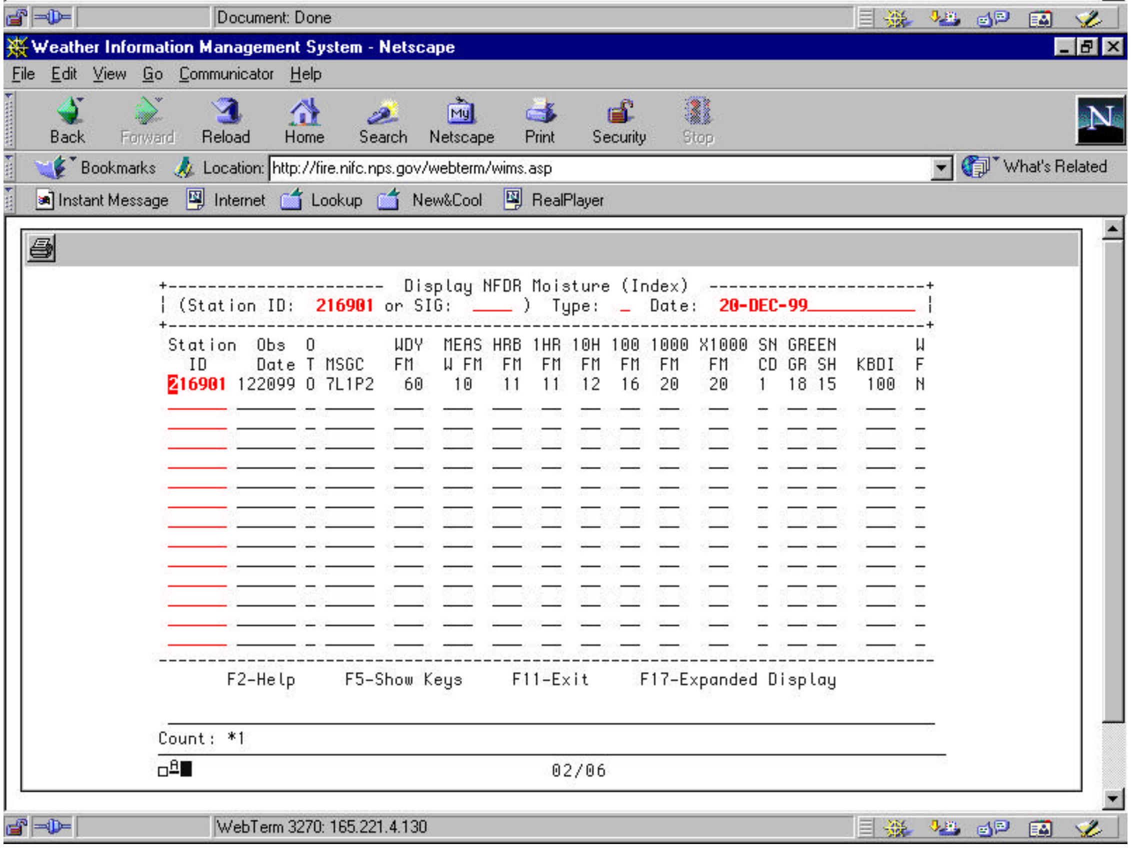
Station ID	Obs Date	Ob Tm	O T	MSGC	WS	WDY	HRB	1H	10	HU	TH	IC	SC	EC	BI	FL	SL	R	KBDI
216901	122099	13	O	7L1P2	13	60	11	11	12	16	20	4	40	1	17	12	2_	L	100
216901	122099	13	O	7R1P2	13	60	11	11	12	16	20	7	4	11	17	12	2_	L	100
216901	122099	13	O	7E1P2	13	60	11	11	12	16	20	7	16	14	36	26	3_	M	100
216901	122099	13	O	7N1P2	13	60	11	11	12	16	20	7	91	14	82	58	5_	H	100

F2-Help F5-Show Keys F11-Exit F17-Expanded Display

Count: *4

03/06

Document: Done


Weather Information Management System - Netscape

Location: http://fire.nifc.nps.gov/webterm/wims.asp

Display NFDR Moisture (Index)

(Station ID: 216901 or SIG: ____) Type: _ Date: 20-DEC-99________

Station ID	Obs Date	O T	MSGC	WDY FM	MEAS W FM	HRB FM	1HR FM	10H FM	100 FM	1000 FM	X1000 FM	SN CD	GREEN GR	SH	KBDI	W F
216901	122099	O	7L1P2	60	10	11	11	12	16	20	20	1	18	15	100	N

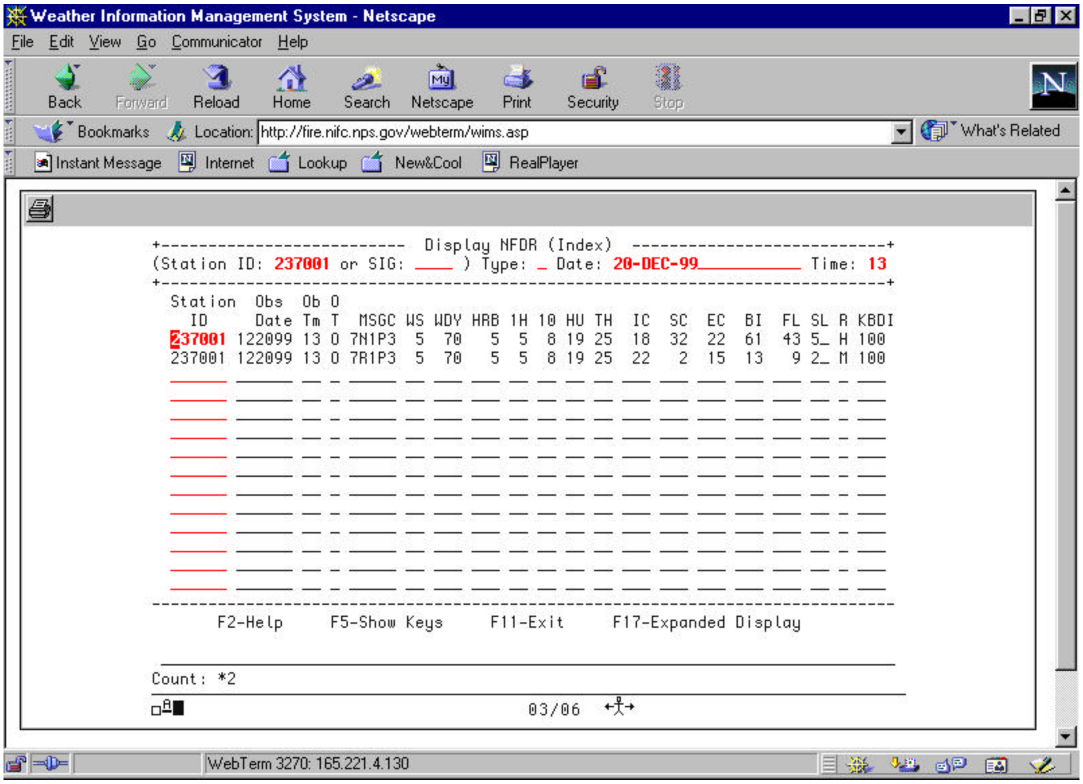
F2-Help F5-Show Keys F11-Exit F17-Expanded Display

Count: *1

02/06

WebTerm 3270: 165.221.4.130

Figure 3. Sample NFDRS output for Pipestone National Monument on December 20, 1999.



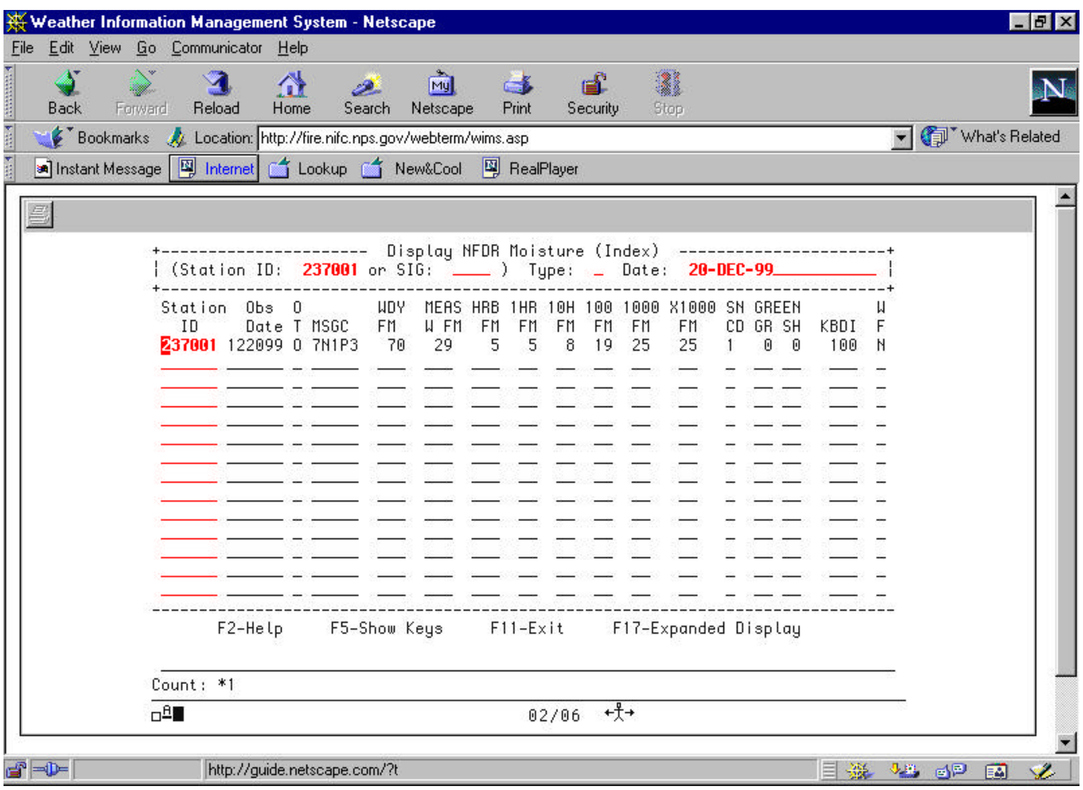


Figure 4. Sample NFDRS output for Wilson's Creek National Battlefield on December 20, 1990.

Appendix A. Campbell Scientific, Inc. field station specifications for Wilson's Creek National Battlefield and Pipestone National Monument

Datalogger

Model CR10X

Temperature range: -25° C to +50° C
Program execution rate: up to 64 Hz
Number of channels: 6 differential, 3 excitation, 2 pulse, 8 control ports
Power requirements: 9.6 to 16 volts
Current drain: 1 mA quiescent
: 13 mA processing
: 46 mA analog measurement
RAM: 128 K Flash and 128 K SRAM standard
Data storage: 62,000 data points

Wind speed and direction

Model 05103 Wind Monitor

Sensors: propeller vane
Temperature range: -50° to +50° C
Wind speed range: 0 to 134 mph, gust survival 220 mph
Wind speed threshold: 2.2 mph
Wind speed distant constant (63% recovery): 8.9 ft
Wind direction damping ratio: 0.25
Wind direction delay distance (50% recovery): 4.3 ft
Vane range: 360° mechanical, 355° electrical
Vane threshold: 2.0 mph @ 10° displacement, 2.9 mph @ 5° displacement

Precipitation

Model TE525 tipping bucket rain gauge (WICR)

Sensor: magnetic switch
Orifice: 6.25" diameter
Sensitivity: 0.01"/tip

Model 385C electric heated tipping bucket rain/snow gauge (PIPE)

Orifice: 12" diameter
Calibration (standard): 0.01" rain per switch closure
(options): 0.2 mm, 0.25 mm
Accuracy: ±1% at 1" to 3" per hour at 70° F
Switch type: magnet and reed
Mounting: 3 pads for 1/4 bolts on 9-21/32" (9.66")
Dimensions: 20" high, 8" diameter, not including mounting pads or funnel
Power requirement: 110 VAC, 50/60 Hz, 315 W
Weight: 7.5 lb/3.4 kg (10 lb shipping with cables)

Snow depth (WICR)

Model SR50 sonic ranging sensor

Power requirements: 9 to 16 VDC
Power consumption: 2 mA (quiescent), 250 mA (measurement peak)
Measurement time: 0.6 seconds (typical), 3.0 seconds (maximum)
Measurement range: 0.5 to 1.0
Accuracy: ±1 cm or 0.4% of distance to target w/ external temperature compensation Resolution: 0.1 mm
Beam acceptance angle: approximately 22°

Solar radiation

Model LI200X silicon pyranometer

Sensor: silicon photocell
Sensitivity: 0.2 $kWm^{-2}mV^{-1}$
Requirements: LI2003S base and leveling fixture

Soil temperature

Model 107B soil temperature probe

Sensor: thermistor
Range: -35° to 50° C
Accuracy: typically ±0.2° C

Air temperature and relative humidity

Model HMP35C temperature and relative humidity probe (WICR)

Sensors: thermistor (specifications are the same as for Model 107B above)
HUMICAP H-sensor
Relative humidity range: 0 to 100% RH
Relative humidity accuracy: ±2% RH (0 to 90% RH)
Temperature range: -35° to +50° C
Temperature accuracy: ±0.2° C

Model CS500 temperature and relative humidity probe (PIPE)

Temperature measurement range: -40° C to +60° C
Temperature accuracy: ±0.5° C @ -40° C, ±0.4° C @ -20° C, ±0.6° C @ +60° C
Relative humidity range: 10 to 90% RH (for the specified accuracy)
Relative humidity accuracy: ±2.0% @ 10%, ±3.0% @ 90%
Typical long-term stability: better than ±1.0% per year
Supply voltage: 7 to 28 VDC
Current consumption: typically < 2 mA
Diameter: 0.47" (12 mm)
Length: 2.66" (68 mm)
Housing material: ABS plastic

Fuel-moisture sensor

Model 1981-CS - Sensor (PIPE)

Microprocessor-controlled device by Laurasoft, Inc.
Accuracy: 10% reading over the range of 5 to 30% fuel moisture content

Model 211-CS - Probe

Contains a temperature sensing circuit that is used to adjust the fuel-moisture readings based on the fuel temperature

Model 439-C - Sensor by Handar (WICR)

Sensing element: Dry ponderosa pine dowel with imbedded wire electrodes
Measurement principal: Capacitance of wood calibrated to read per cent of moisture by weight
Accuracy: 0 to 12% FM: ± 1.9% FM RMSE - 2 week period
12 to 30% FM: ± 3.6% FM RMSE
>30% FM: ± 16% FM RMSE (% FM = measured fuel moisture units)
Power supply: 10 to 14 V measuring current 10mA

Temperature

Type: Single thermistor
Conversion table range: -50° C to +50° C
Accuracy: ± 0.2° C, -20° C to + 80° C

Physical dimensions

Size: Base diameter 1.125 in (28.6 mm) - overall length 12 in (305 mm)
Weight: 4.4 oz (125 gm)

Multiplexer

Model AM416 Relay multiplexer (WICR)

Power source: unregulated 12 V (9.6 V to 16 V)
Current drain: <100 uA (quiescent), 17mA (active) (typical)
Reset: A continuous signal of 3.5 V ?voltage ?16 V holds in an active state
Clock: On the transition from <1.5 V to >3.5 V, scan advance is actuated on the leading edge of the clock signal; clock signal must be a minimum of 5 ms in width
Operational temperature: -40° C to +65° C
Operational humidity: 0 to 95%, non-condensing
Dimensions (w/o field enclosure): L-25.4 cm (8.2"), W-16.5 cm (6.5"), D-3.5 cm (1.5")
Dimensions (w/ field enclosure): L-25.4 cm (10"), W-20.3 cm (8"), D-10.2 cm (4")
Weight: 1.5 lbs. (approximately), (In enclosure): 10.0 lbs. (approximately)
Expandability (nominal): 3AM416'S/CR10(X), 4 AM416'S/21X, 8 AM416'S/CR7 725 card
Maximum switching current: 500 mA

Soil moisture sensor

Model CS615 water content reflectometer

Dimensions: Rods - 30.0 cm long, 3.2 mm diameter, 3.2 cm spacing
Head - 11.0 cm x 6.3 cm x 2.0 cm

Weight: Probe - 280 g
Cable - 35 g m-1

Electrical: Power - 70 milliamps @ 12 VDC (enabled)
- less than 10 microamps (quiescent)

Power supply voltage: 9 VDC (minimum), 18 VDC (maximum), 1.3 VDC (enabled)

Accuracy: 2% (general calibration) - depends on soil texture and mineral composition

Resolution: on the order of 10^{-6} m^3 m^{-3}

Antenna (WICR)

Model ASP962 nine element Yagi directional antenna

Gain: 8 dB (806 to 894 MHz)

Communication Package

Model Motorola S1765 transceiver (WICR)

Operating temperature: -30° C to +60° C
Average current drain: 0.38 A (standby), 2.1 A (online)
Supply voltage: 10.9 to 16.3 VDC
Antenna termination: mini UHF

Model DC112 modem (WICR)

Standards: Bell 212A, CCITT V.22
Baud rates: 300, 1200
Operation: full-duplex over standard telephone lines
Operating voltage: 5 volts from the datalogger
Operating temperature: -25° C to +50° C

Model COM200 (PIPE)

Standards: Bell 212, CCITT V.22 and V.32
V.42 LAPM and MNP2-4 error correction
Baud rates: 1200 to 9600
Current drain: 120 mA (quiescent)
140 mA (active)
Power supply: 12 VDC internally switched to minimize current drain
Operating temperature: -25° C to +50° C

Power supply

Model MSX10

10-watt solar panel with mounts

Model PS121LA (PIPE)

12-volt lead acid battery with charging regulator

Model ST60-2G27-12V (WICR)

12-volt solar electric generator

Appendix B. Sample monthly status report: December 1998 Weather Monitoring for Wilson's Creek National Battlefield

Wilson's Creek National Battlefield
Republic, Missouri

May 2001
Monthly Weather Report

By
F. Adnan Akyüz, Ph.D.
State Climatologist
Missouri Climate Center
University of Missouri-Columbia
100 Gentry Hall
Columbia, Missouri 65211

REFERENCE NOTES

Temperature

Column

2: Maximum Temperature in degrees F averaged over 1-min interval.
3: Minimum Temperature in degrees F averaged over 1-min interval.
4: Daily Average Temperatures in degrees F.
5: Daily average normal temperature (1961-1990) for Springfield Regional Airport (SGF), reported by the National Weather Service.
6: Average temperatures' departure from Springfield's normal.
Col. 6 = Col. 4 – Col. 5
7: Heating Degree Days (HDD) in degrees F, based on 65 °F.
8: Cooling Degree Days (CDD) in degrees F, based on 65 °F.

Precipitation

Column

9: Daily rainfall totals in inches.
10: Accumulated snow depth in inches.
11: Daily snowfall totals in inches.
12: Days passed since the last precipitation event.

Wind

Column

13: Maximum wind speed averaged over 1-min interval in miles per hour.
14: Daily average wind speed averaged over 1440 minutes.
15: Resultant wind vector averaged over 1440 minutes.

Solar Radiation

Column

16: Daily total global solar radiation on a horizontal surface in MJ/m^2.
17: Daily incoming solar radiation at the top of the atmosphere (insolation) as a function of latitude and day of year in units of MJ/m^2.
18: Ratio of the daily total global solar radiation (Col.16) to the insolation (column 17): Attenuation (incoming solar radiation loss) by the atmosphere.

Table B-1. Wilson's Creek National Battlefield monthly summary, December 1998.

	Temperature (°F)					Deg Days		Precipitation(in)				Wind(mph)			Solar Rad (MJ/m²)		
Date	Maximum	Minimum	Average	Normal(SGF)	Departure	Heating	Cooling	Rainfall	Snow Depth	Snowfall	Drought Period	Max 1-min	Average	Direction	Daily Total	Insolation	Rad. Index
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	67	34	50	40	10	15	0	0.00	0.00	0.00	1	5.7	1.5	149	9.75	16.74	0.58
2	71	33	52	40	12	13	0	0.00	0.00	0.00	2	5.9	1.7	161	8.07	16.71	0.48
3	73	53	63	39	24	2	0	0.00	0.00	0.00	3	6.2	1.4	167	6.18	16.67	0.37
4	64	41	53	39	14	12	0	0.30	0.00	0.00	0	5.2	1.0	147	3.76	16.64	0.23
5	77	42	60	38	22	6	0	0.00	0.00	0.00	1	7.0	1.9	160	8.24	16.60	0.50
6	72	37	54	38	16	11	0	0.34	0.00	0.00	0	10.5	3.0	157	3.11	16.57	0.19
7	39	36	38	38	0	27	0	0.01	0.00	0.00	0	6.2	1.9	349	1.48	16.53	0.09
8	46	19	32	37	-5	33	0	0.00	0.00	0.00	1	5.0	1.2	328	9.58	16.50	0.58
9	50	15	32	37	-5	33	0	0.00	0.00	0.00	2	6.5	0.7	152	9.36	16.46	0.57
10	45	22	33	37	-4	32	0	0.00	0.00	0.00	3	3.7	0.5	313	3.11	16.43	0.19
11	49	18	33	36	-3	32	0	0.00	0.00	0.00	4	4.3	0.5	144	7.28	16.40	0.44
12	46	33	39	36	3	26	0	0.15	0.00	0.00	0	4.3	0.6	324	1.82	16.36	0.11
13	52	21	36	36	0	29	0	0.00	0.00	0.00	1	4.6	0.7	319	7.80	16.33	0.48
14	57	20	38	36	2	27	0	0.00	0.00	0.00	2	4.6	0.5	139	9.70	16.29	0.60
15	60	16	38	35	3	27	0	0.00	0.00	0.00	3	3.6	0.5	196	9.70	16.26	0.60
16	52	26	39	35	4	26	0	0.00	0.00	0.00	4	6.4	1.7	293	7.71	16.22	0.48
17	49	28	39	35	4	26	0	0.00	0.00	0.00	5	5.0	1.4	276	9.62	16.19	0.59
18	57	34	45	34	11	20	0	0.58	0.00	0.00	0	6.4	2.0	151	2.74	16.15	0.17
19	41	31	36	34	2	29	0	0.19	0.00	0.00	0	7.2	2.0	357	1.42	16.12	0.09
20	43	32	37	34	3	28	0	0.04	0.00	0.00	0	5.1	1.6	89	1.27	16.08	0.08
21	35	11	23	34	-11	42	0	0.04	0.00	0.00	0	8.1	3.7	339	0.79	16.05	0.05
22	22	4	13	34	-21	52	0	0.01	0.00	0.00	0	8.5	2.0	358	9.08	16.01	0.57
23	23	14	19	33	-14	46	0	0.00	0.00	0.00	1	5.5	2.0	37	3.39	15.98	0.21
24	33	7	20	33	-13	45	0	0.00	0.00	0.00	2	4.5	1.0	350	8.85	15.94	0.56
25	37	6	22	33	-11	43	0	0.00	0.00	0.00	3	5.0	0.7	190	7.56	15.91	0.47
26	47	11	29	33	-4	36	0	0.00	0.00	0.00	4	7.1	1.4	153	9.12	15.87	0.57
27	54	26	40	32	8	25	0	0.00	0.00	0.00	5	6.5	1.2	210	7.88	15.84	0.50
28	50	15	32	32	0	33	0	0.00	0.00	0.00	6	6.0	1.2	152	7.41	15.80	0.47
29	40	17	29	32	-3	36	0	0.00	0.00	0.00	7	10.5	3.1	329	4.64	15.77	0.29
30	31	11	21	32	-11	44	0	0.00	0.00	0.00	8	6.4	1.9	129	4.19	15.73	0.27
31	31	16	23	32	-9	42	0	0.00	0.00	0.00	9	6.8	1.4	334	8.89	15.70	0.57
Average	49	23	36	35	1	29	0				2	6.1	1.5		6.24		0.38
Maximum	77	53	63	40	23	52	0				9	10.5	3.7		9.75		0.60
Minimum	22	4	13	32	0	2	0				0	3.6	0.5		0.79		0.05
Total						897	0	1.66	0.00	0.00	22				193.49		

September Statistics
Number of Days With
Max Temp ≥ 90°F 0
Max Temp ≤ 32°F 4
Min Temp ≤ 32°F 22
Min Temp ≤ 0°F 0
Precipitation ≥ 0.01in 9
Precipitation ≥ 0.1in 5
Precipitation ≥ 1in 0
Average Temp > 65°F 0
Average Temp < 65°F 31

Table B-2. Wilson's Creek National Battlefield monthly soil temperature data, December 1998.

Month and Day	Max ST RH (°F)	Min ST RH (°F)	Max ST WSG (°F)	Min ST WSG (°F)	Max ST MH (°F)	Min ST MH (°F)	Max ST DL (°F)	Min ST DL (°F)
1-Dec	60.0	46.9	54.1	50.1	56.8	50.2	58.6	49.4
2-Dec	60.0	44.1	54.6	47.7	56.5	47.4	59.6	48.5
3-Dec	63.3	52.0	58.4	53.1	59.9	52.7	60.5	54.9
4-Dec	60.6	49.9	56.8	52.4	58.6	52.4	57.2	52.7
5-Dec	63.9	48.9	58.1	51.7	60.6	51.7	61.1	51.9
6-Dec	62.5	50.3	59.3	53.1	60.5	53.2	60.7	51.9
7-Dec	50.3	46.1	53.1	49.2	53.3	49.9	51.9	47.6
8-Dec	52.1	37.9	49.2	42.5	50.7	42.3	51.9	42.9
9-Dec	47.3	34.5	43.9	39.2	46.9	39.1	48.9	39.7
10-Dec	44.8	36.5	44.2	40.2	46.3	40.5	44.8	41.4
11-Dec	45.1	33.8	43.0	37.8	45.4	37.8	45.5	38.6
12-Dec	45.1	38.6	44.5	40.9	46.6	42.0	45.1	42.3
13-Dec	47.9	35.3	44.4	39.5	46.7	39.5	47.1	40.1
14-Dec	48.8	34.8	43.2	38.5	46.6	38.4	49.1	39.4
15-Dec	47.3	33.4	41.8	36.5	45.4	36.5	48.1	37.8
16-Dec	49.0	35.4	44.2	38.2	47.0	38.4	46.8	40.5
17-Dec	46.1	34.4	42.1	38.6	44.6	38.1	47.7	39.9
18-Dec	44.7	35.2	43.7	38.8	45.0	38.5	45.5	40.9
19-Dec	42.6	39.1	43.8	41.7	45.2	43.4	44.5	41.1
20-Dec	43.3	39.0	44.0	41.6	46.2	43.2	44.1	41.0
21-Dec	42.1	33.5	43.6	36.9	45.4	37.3	43.3	36.6
22-Dec	33.5	31.5	36.9	34.2	37.3	34.8	36.6	35.2
23-Dec	31.9	30.7	34.6	34.1	36.3	34.7	35.2	34.8
24-Dec	31.8	28.8	34.5	33.3	36.7	34.0	35.0	34.5
25-Dec	31.8	26.7	33.3	32.1	34.4	33.4	34.6	34.2
26-Dec	31.9	27.2	32.9	31.9	34.3	33.4	35.1	34.1
27-Dec	32.1	31.2	34.2	32.9	39.0	34.1	40.7	35.0
28-Dec	36.2	32.0	35.4	33.5	39.8	34.5	40.5	36.2
29-Dec	37.6	32.3	36.4	34.6	39.1	35.1	39.4	35.9
30-Dec	32.3	31.5	34.6	33.8	35.5	34.1	35.9	34.8
31-Dec	31.9	30.7	34.3	33.7	36.6	34.1	34.9	34.3
Average	45.1	36.8	43.8	40.1	45.9	40.5	46.1	40.9
Maximum	63.9	52.0	59.3	53.1	60.6	53.2	61.1	54.9
Minimum	31.8	26.7	32.9	31.9	34.3	33.4	34.6	34.1

ST: Soil Temperature
RH: Rocky Habitat
WSG: Warm Season Grass Habitat
MH: Mixed Habitat
DL: Drip Line Habitat

Table B-3. Wilson's Creek National Battlefield monthly soil moisture data, December 1998.

Month and Day	Avg SM RH (%)	Avg SM WSG (%)	Avg SM MH (%)	Avg SM DL (%)
1-Dec	51	42	40	36
2-Dec	49	41	39	35
3-Dec	49	40	38	34
4-Dec	53	44	42	37
5-Dec	52	43	41	37
6-Dec	53	45	43	38
7-Dec	53	44	42	38
8-Dec	51	42	40	36
9-Dec	49	40	39	36
10-Dec	48	39	38	35
11-Dec	46	38	37	35
12-Dec	50	40	39	36
13-Dec	52	42	41	37
14-Dec	50	40	39	36
15-Dec	47	39	38	35
16-Dec	48	39	38	35
17-Dec	46	38	37	34
18-Dec	49	41	40	35
19-Dec	55	49	48	40
20-Dec	52	43	42	38
21-Dec	53	44	43	38
22-Dec	36	36	38	32
23-Dec	21	34	36	30
24-Dec	14	31	34	28
25-Dec	12	26	26	26
26-Dec	13	25	22	25
27-Dec	16	28	28	32
28-Dec	22	30	32	35
29-Dec	33	32	33	35
30-Dec	17	29	28	31
31-Dec	12	28	28	30
Average	40	38	37	34
Maximum	55	49	48	40
Minimum	12	25	22	25

RH: Rocky Habitat
WSG: Warm Season Grass Habitat
MH: Mixed Habitat
DL: Drip Line Habitat
SM: Soil Moisture
%: % By volume

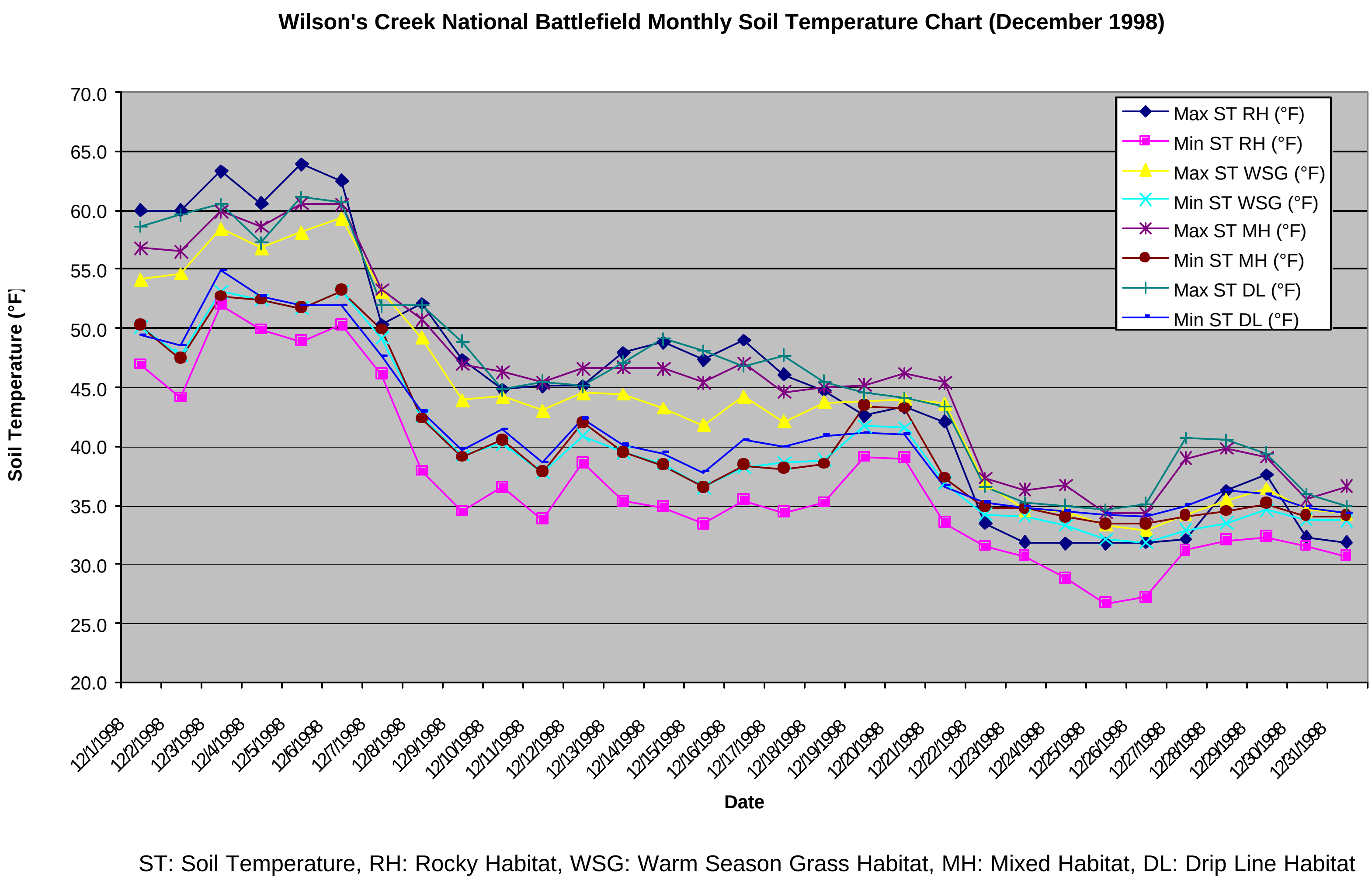
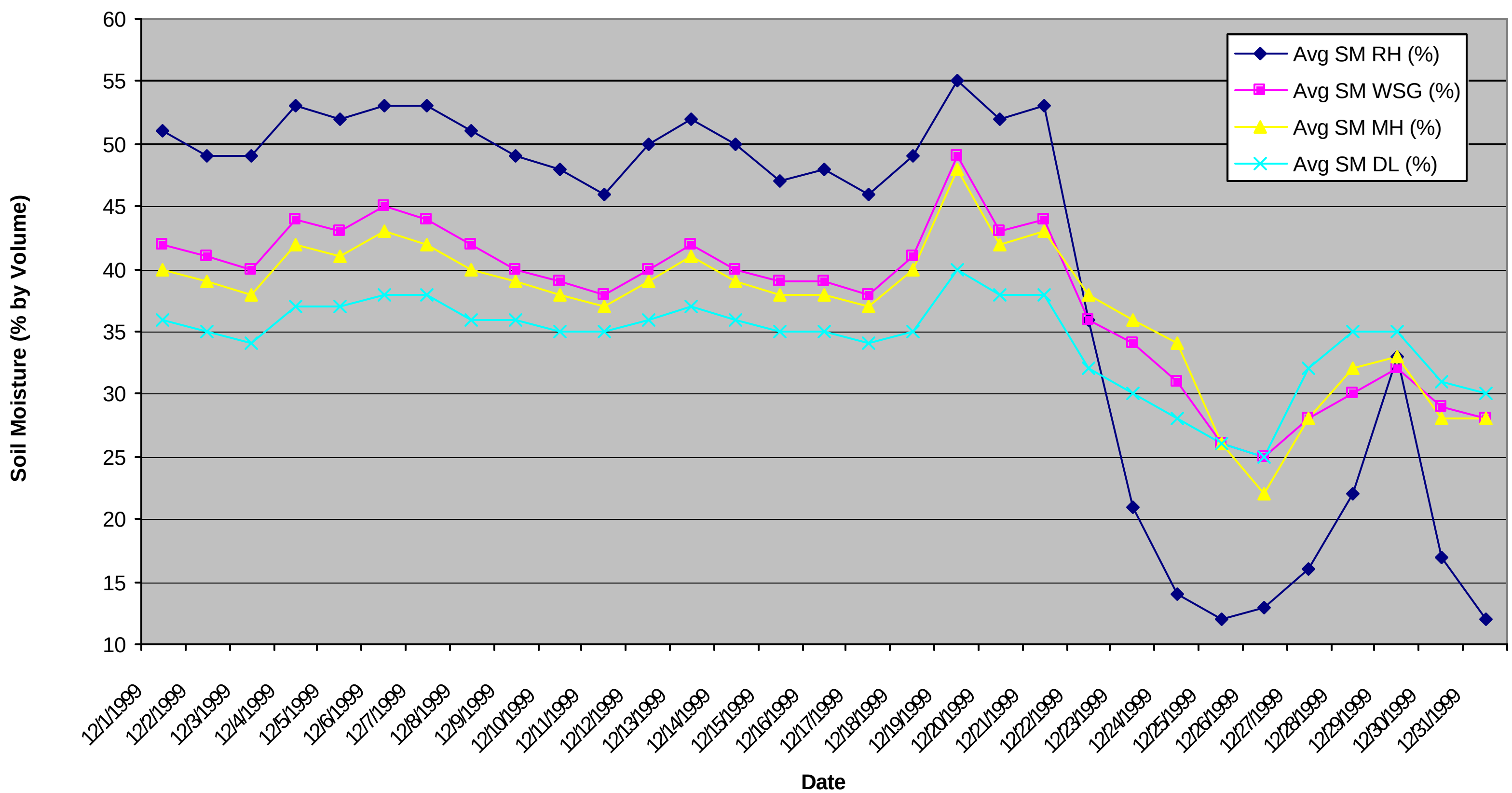


Figure B-1. Wilson’s Creek National Battlefield, monthly soil temperature chart, December 1998.

Wilson's Creek National Battlefield Monthly Soil Moisture Chart (December 1998)



SM: Soil Moisture, RH: Rocky Habitat, WSG: Warm Season Grass Habitat, MH: Mixed Habitat, DL: Drip Line Habitat

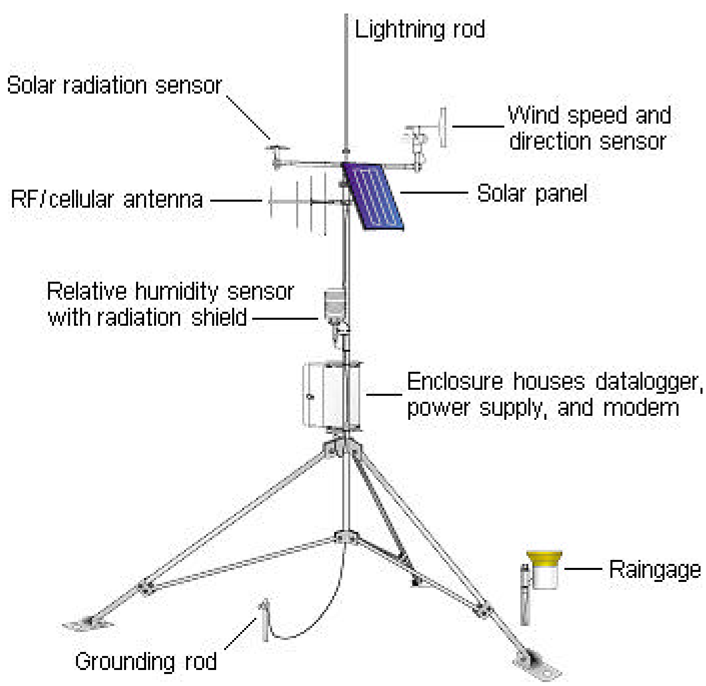
Figure B-2. Wilson's Creek National Battlefield, monthly soil moisture chart, December 1998.

Appendix C. Sample annual status report: 1996 Weather Monitoring for Wilson's Creek National Battlefield

Prairie Cluster Long-Term
Ecological Monitoring Program

Program Report
96-002

Annual status report:
1996 Weather Monitoring at
Wilson's Creek National Battlefield



Annual status report:

1996 Weather Monitoring for Wilson's Creek National Battlefield

By

F. Adnan Akyüz, Ph.D.
U.S. Geological Survey
Biological Resources Division
Northern Prairie Wildlife Research Center
Missouri Field Station
University of Missouri-Columbia
301 Gentry Hall
Columbia, Missouri 65211

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1.0 INTRODUCTION

The National Park Service will focus monitoring in the Prairie Cluster Long Term Ecological Monitoring (LTEM) Parks on terrestrial plant communities and rare plant populations. Weather and climate affect the structure and function of grassland systems, including plant production, and species composition and diversity. Continuous weather monitoring is a key factor in separating the effects of climate from the effects of management actions on plant community and population dynamics. Wilson's Creek National Battlefield (WICR) began weather monitoring in 1995.

2.0 OBJECTIVES

The objectives of weather monitoring at WICR are to provide park managers and cooperators with 1) monthly and annual summaries of glade weather and to collect soil temperature and moisture data within different glade microhabitats as potential predictors of population dynamics of the endangered Missouri bladderpod and 2) input data for fire behavior simulation models.

3.0 METHODS

An automated weather station was installed at North Bloody Hill glade to measure atmospheric variables including air temperature, relative humidity, solar radiation, wind speed and direction, rainfall, and snow depth and to measure soil temperature and moisture at three glade habitats of the endangered Missouri bladderpod. In addition, the weather station measures fuel moisture and temperature. The weather station (Campbell Scientific, Inc., Model CM10 field station) automatically collects data from sensors at 1-minute intervals and stores data in a datalogger. A meteorologist at the Missouri Field Station located within the Department of Soil and Atmospheric Sciences, at the University of Missouri-Columbia retrieves stored data daily via modem and cellular phone. The meteorologist checks the quality of the data against weather variable and instrument range limits using the software program SPLIT (Campbell Scientific, Inc.) and archives the data in comma-delineated ASCII format on the field station's weather computer.

4.0 RESULTS

4.1 Weather in 1996

The annual average temperature was 54°F, 2° below the 30-year normal recorded at the nearest National Weather Service Reporting Station at Springfield (SGF), Missouri. Monthly mean temperatures recorded at the North Bloody Hill glade were below normal when compared to SGF in nine months of the year (Table 1 and Figure 1). Daily temperatures ranged from a maximum of 99° on August 6 to a minimum of –17° on February 4, whereas the daily temperatures at SGF ranged from a maximum of 97° on August 6 to a minimum of –8° on February 4. Daily maximum temperatures were 90° or higher on 50 days, whereas they were 90° or higher on 22 days at SGF. Likewise, daily minimum temperatures were 32° and below on 127 days at WICR, whereas they were 32° and below on 107 days at SGF (Table 3). The continuous frost free period extended 172 days from April 21 to October 11, as compared to a 207-day period extending from April 6 to October 31 at SGF. Figure 1 graphically compares the annual distribution of monthly average maximum and minimum temperatures for 1996 at WICR and SGF with the 30-year average of monthly maximum and minimum temperatures at SGF.

In contrast to annual average temperature, the total annual precipitation of 42.99 inches recorded at WICR was very near the normal (43.04 inches) recorded at SGF. Monthly average precipitation ranged from a minimum of 0.60 inches in February to a maximum of 7.59 inches in November (Table 1 and Figure 2). Figure 2 also shows the 30-year average of monthly total precipitation at SGF. A 24-hour precipitation total of 1 inch or greater was reported on 13 days. The greatest 24-hour rainfall was 3.29 inches on September 26, as compared to 3.90 inches of rain at SGF on the same day. SGF reported a total rainfall of 44.86 inches in 1996. Snow/ice of at least 1 inch in depth covered the ground for 14 days in 1996 with the greatest depth of 3.86 inches recorded on January 2 (Table 1).

Table 1 shows monthly and annual weather data for most of the variables measured on the North Bloody Hill glade in 1996. It follows the format used by the National Oceanic and Atmospheric Administration (NOAA) to report Local Climatological Data (NOAA 1996).

4.2 Soil Temperature and Moisture

Average soil temperature for each of the three Missouri bladderpod habitats was nearly the same for the months January to April and September through December. In the summer months, the rocky habitat had the highest average temperature. Maximum and minimum soil temperatures were more variable among habitats but for the warm season grass habitat, maximum soil temperatures were consistently lower and minimum soil temperatures were consistently higher throughout the year (Table 2 and Figure 3).

Soil moisture data for the three habitats were not reported since the soil moisture sensors were not reliable. New sensors will be installed in 1997.

4.3 Fuel Moisture

Fuel moisture data were not reported. However, park managers used real-time monitoring to obtain fuel moisture data for fire-weather model input.

5.0 DISCUSSION

In 1996, the weather at the North Bloody Hill glade mirrored the weather trend at SGF with both stations reporting below normal average monthly temperatures and near normal total monthly precipitation. Figure 1 graphically compares the monthly maximum and minimum temperatures recorded at WICR and SGF with the normal maximum and minimum temperatures at SGF. Glades are characterized by xeric conditions much of the growing season and a unique flora adapted to extremes of temperature and moisture (Ladd and Nelson 1982). The differences between the glade environment and SGF are evident when temperatures recorded at WICR are compared to temperatures recorded at SGF. For every month of 1996, mean maximum temperatures were higher, and mean minimum temperatures were lower; therefore, the temperature range at WICR was greater as compared to SGF (Figure 4). As another indication of the extreme temperature environment on the glade, the number of days with temperatures greater than 90° and number of days with temperatures below 32° were compared between reporting sites (Table 3). The North Bloody Hill glade had 28 more days with temperatures of 90° and above, and 20 more days with temperatures at or below freezing. Furthermore, in 1996, the highest maximum temperature recorded for the glade was 2° higher than the highest maximum temperature at SGF and the lowest minimum temperature recorded for the glade was 9° lower than the lowest minimum temperature at SGF.

In 1996, the exposed rocky habitat had the highest maximum soil temperature (106°) (Table 1) and far greater number of days with a maximum temperature of 100° and above and a minimum temperature of 32° and below (Table 2). Differences in soil temperature among the glade habitats reflect the extreme climate of the glade and may partially account for differences in germination and survival of the Missouri bladderpod (Thomas 1996).

6.0 REFERENCES

Ladd, D. and P. Nelson. 1982. Ecological synopsis of Missouri glades. In: E. A. McGinnes, editor. Proceedings of Cedar Glade Symposium. The Missouri Academy of Science Occasional Paper 7.

National Oceanic and Atmospheric Administration. 1997. Local Climatological Data. National Climatic Data Center, Asheville, North Carolina.

Thomas, L. P. 1996. Population ecology of a winter annual (*Lesquerella filiformis* Rollins) in a patchy environment. Natural Areas Journal 16:216-226.

7.0 REFERENCE NOTES

Temperature (°F)

Daily Max: Monthly average of the daily maximum temperatures.
Daily Min: Monthly average of the daily minimum temperatures.
Monthly: Monthly average of the daily average temperatures.
Departure: Departure from 30-year average recorded at the nearest National Weather Service (NWS) reporting station, Springfield Regional Airport, Missouri (SGF)
Highest: Highest temperature of the month.
Lowest : Lowest temperature of the month.
Date: The date when Highest and lowest temperatures were observed.
# of days with: Number of days with temperatures greater than or equal to, or less than or equal to a threshold value.

Degree Days (Base 65 °F)

Heating: Monthly total Heating Degree Days (HDD).
Cooling: Monthly total Cooling Degree Days (CDD).

Precipitation (inch)

Total: Monthly total water equivalent.
Departure: Departure from SGF normal precipitation.
Greatest 24-hr: Greatest amount of precipitation fell in 24-hour period.
Date: The date when the greatest amount of precipitation fell in 24-hour period.
# of days with: Number of days with precipitation greater than or equal to, or less than or equal to a threshold value.

Wind (mph)

Avg Max: Monthly average of the daily maximum wind speed.
Fastest 1-min: The fastest wind speed averaged over 1 minute of the month.
Date: The date when the fastest 1-min wind was observed.

Solar Radiation (MegaJules/ m^2)

Averages: Monthly average of the daily total solar radiation.
Radiation Index: Ratio of the monthly average of the daily total solar radiation to daily incoming solar radiation (insolation) at the top of the atmosphere.

Table C-1. Summary of 1996 annual weather data at North Bloody Hill Glade.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°F)													
Averages													
Daily Max	43	54	53	69	79	87	88	90	80	71	49	51	68
Daily Min	18	21	26	35	55	57	62	60	49	41	30	24	40
Monthly	30	37	40	53	67	72	74	74	64	55	39	37	54
Departure	-1	1	-6	-3	2	-1	-4	-2	-5	-2	-7	2	-2
Extremes													
Highest	73	80	78	88	92	96	97	99	95	83	76	74	99
Date	14	26	13	19	24	30	20	6	11	16	5	10	Aug 6
Lowest	-8	-17	2	18	35	44	53	51	34	25	13	1	-17
Date	8	4	9	6	2	4	25	14	28	19	27	20	Feb 4
# of Days with													
Max Temp $ 90°F	0	0	0	0	2	14	14	15	5	0	0	0	50
Max Temp # 32°F	7	4	2	0	0	0	0	0	0	0	2	4	19
Min Temp # 32°F	29	23	19	10	0	0	0	0	0	6	16	24	127
Min Temp # 0°F	3	3	0	0	0	0	0	0	0	0	0	0	6
Degree Days (Base 65°F)													
Heating	1085	812	775	360	0	0	0	0	30	310	780	868	5020
Cooling	0	0	0	0	62	210	279	279	0	0	0	0	830
Precipitation (in)													
Water Equivalent													
Total	2.80	0.60	1.94	5.54	4.75	2.98	3.84	1.83	6.83	3.03	7.59	1.26	42.99
Departure	1.01	-1.57	-1.95	1.36	0.37	-2.11	0.92	-1.68	2.21	-0.55	3.84	-1.90	-0.05
Greatest 24-hr	0.99	0.31	0.58	2.09	0.85	1.42	1.24	0.97	3.29	1.26	2.29	0.68	3.29
Date	18	26	28	21	5	15	14	18	26	27	6	23	Sep26
Snow, Hail, etc.													
Max on the Ground	3.86	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81	0.00	3.86
Date	2	4									25		Jan 2
# of Days with													
Tot Precip $ 0.01in	12	6	10	7	12	9	8	9	11	8	16	10	118
Tot Precip $ 1in	0	0	0	3	0	1	2	0	3	1	3	0	13
Wind (mph)													
Avg Max	8	9	9	10	8	6	6	6	7	7	7	8	8
Fastest 1-min	14	14	15	17	11	15	11	9	15	10	13	16	17
Date	17	15	24	28	5	18	22	18	23	29	16	2	Apr28
Solar Radiation (MJ/m^2)													
Average	7.69	12.18	14.00	17.88	18.75	22.90	21.08	19.87	15.81	12.87	6.05	7.52	14.72
Radiation Index	0.44	0.549	0.492	0.515	0.484	0.576	0.542	0.547	0.505	0.517	0.314	0.463	0.495

Table C-2. Summary of 1996 annual soil temperature data at North Bloody Hill.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Soil Temperature (°F)														
Averages														
Daily Max														
	RH	38	49	56	71	84	93	94	92	82	70	49	44	68
	WSG	38	44	50	63	73	78	81	80	73	64	47	44	61
	MH	39	49	56	72	85	90	88	87	77	66	50	44	67
Daily Min														
	RH	33	34	38	47	63	70	74	72	63	53	40	34	52
	WSG	35	37	41	50	63	68	72	72	65	57	44	39	54
	MH	34	35	38	46	62	67	72	70	62	54	43	37	52
Monthly														
	RH	35	40	45	58	72	80	83	81	71	61	44	39	59
	WSG	36	40	45	56	67	73	76	76	69	60	47	41	57
	MH	36	40	45	57	71	77	79	77	69	59	46	40	58
Extremes														
Highest														
	RH	55	69	69	85	100	105	106	104	97	78	62	56	106
	WSG	51	60	59	72	82	86	87	87	80	68	59	52	87
	MH	55	69	70	87	105	105	96	94	90	72	60	54	105
Lowest														
	RH	25	22	28	35	49	59	65	67	50	44	33	22	22
	WSG	32	26	32	40	53	61	67	68	56	51	36	32	26
	MH	29	28	30	36	48	59	64	64	53	45	35	30	28
# of Days with														
Max ST $ 90°F														
	RH	0	0	0	0	11	20	21	22	10	0	0	0	84
	WSG	0	0	0	0	0	0	0	0	0	0	0	0	0
	MH	0	0	0	0	12	17	14	6	0	0	0	0	49
Min ST # 32°F														
	RH	9	8	3	0	0	0	0	0	0	0	0	8	28
	WSG	1	8	0	0	0	0	0	0	0	0	0	0	9
	MH	4	7	3	0	0	0	0	0	0	0	0	2	16

* All soil temperature probes are buried 1" under ground level.

RH: Rocky Habitat
WSG: Warm Season Grass Habitat
MH: Mixed Habitat

Table C-3. Number of days with maximum temperatures of 90°F and above, and minimum temperatures 32° F and below at Wilson's Creek National Battlefield (WICR) and Springfield (SGF), Missouri.

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Number of Days	**Max Temp $ 90°F**	**WICR**	0	0	0	0	2	14	14	15	5	0	0	0	**50**
		SGF	0	0	0	0	0	5	10	6	1	0	0	0	**22**
	Min Temp # 32°F	**WICR**	29	23	19	10	0	0	0	0	0	6	16	24	**127**
		SGF	28	19	18	4	0	0	0	0	0	2	15	21	**107**

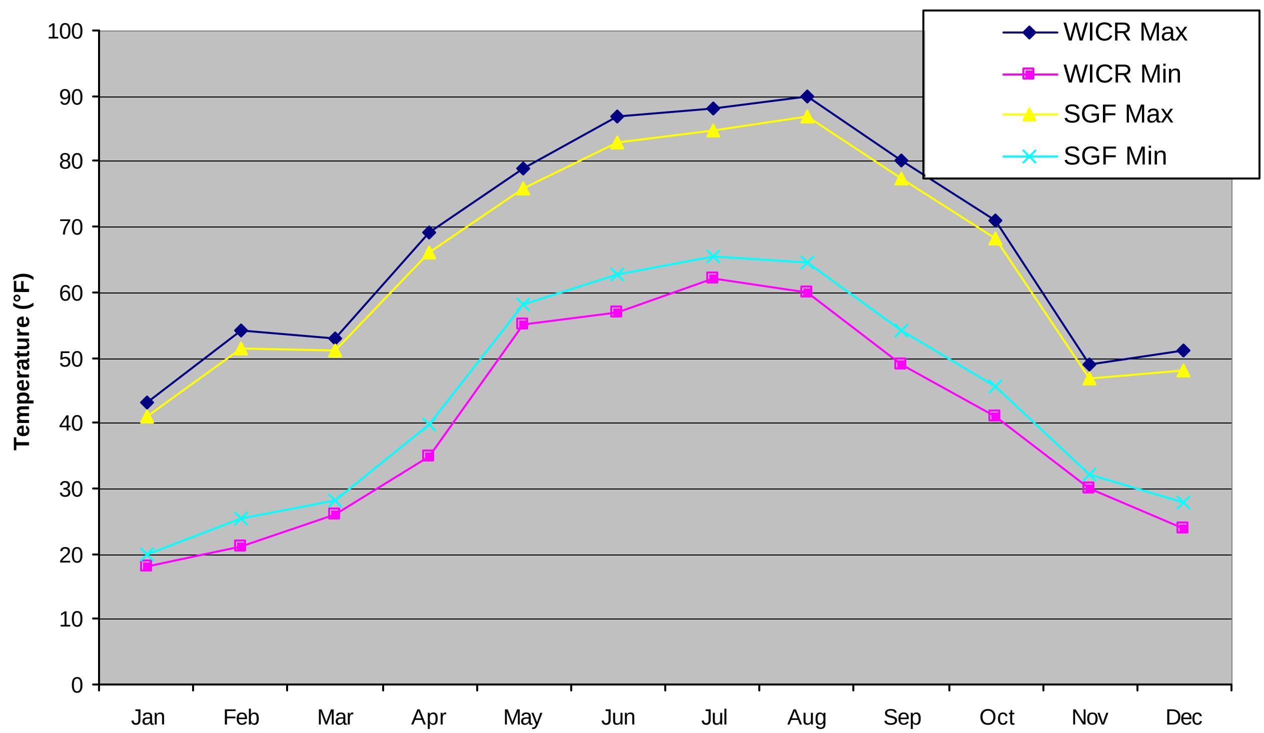


Figure C-1. 1996 monthly average maximum and minimum temperatures at Wilson's Creek National Battlefield (WICR) and Springfield National Weather Service (SGF), Missouri.

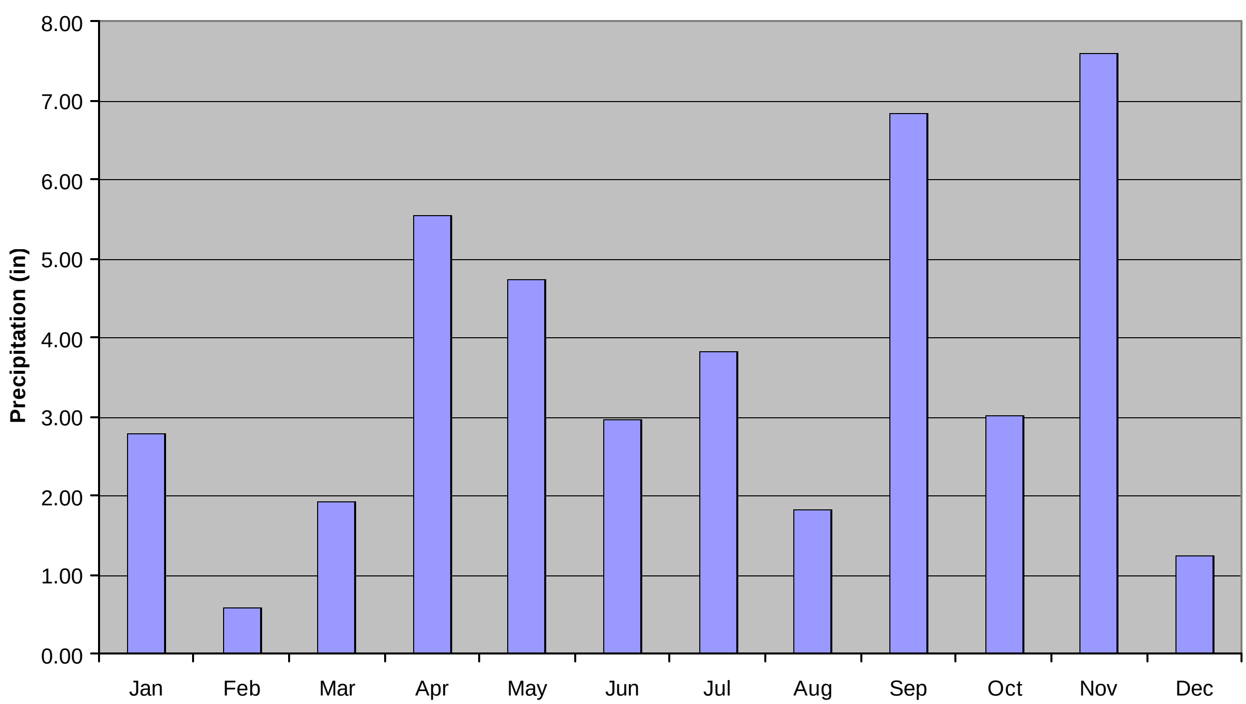


Figure C-2. 1996 monthly precipitation at Wilson's Creek National Battlefield (WICR), Missouri.

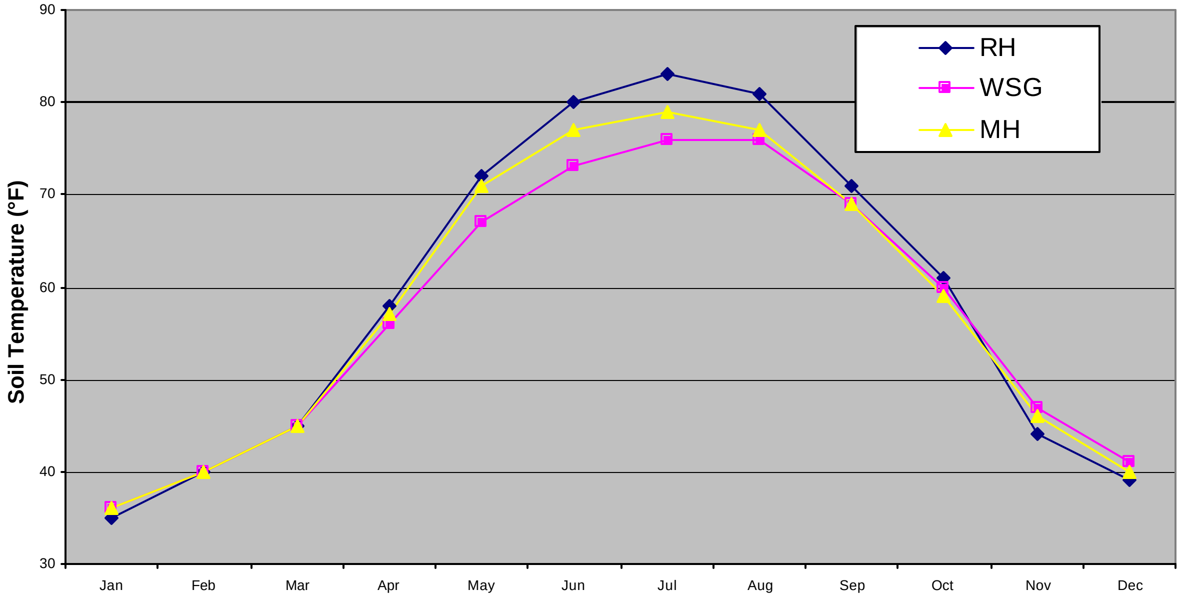


Figure C-3. 1996 monthly average soil temperatures for 3 glade microhabitats (RH: Rocky Habitat, WSG: Warm Season Grass Habitat, and MH: Mixed Habitat) at Wilson's Creek National Battlefield, Missouri.

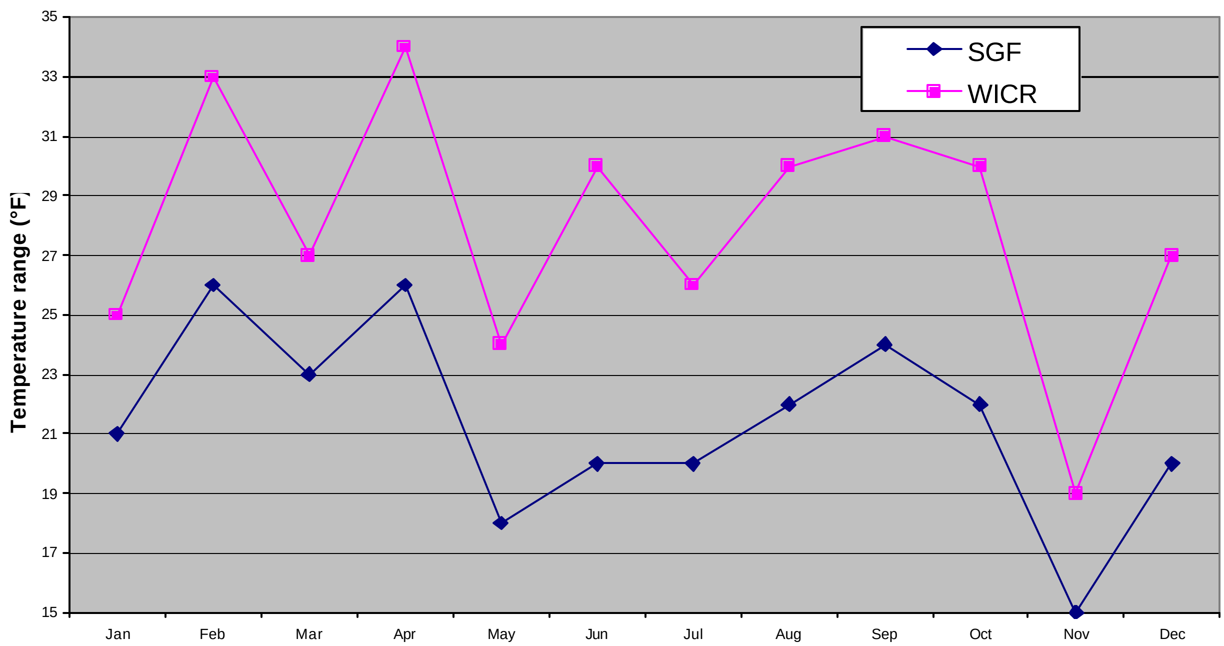


Figure C-4. 1996 monthly average of daily temperature range at Wilson's Creek National Battlefield (WICR) and Springfield National Weather Service (SGF), Missouri.

Appendix D. Sample weather station maintenance log

MAINTENANCE LOG

STATION: Pipestone

Date	Service/maintenance performed
10-20-95	- installed 200' soil moisture probe - installed 200' soil temperature probe - calibrated rain gauge - leveled pyranometer - cleaned solar panel

Name of person who performed service: Dr. Adnan Akyüz

RAWS MAINTENANCE NARRATIVE

On _____________, _____________ and ____________ from the Remote Sensing Fire Weather Support Unit visited you district to perform maintenance and/or calibration on the ___________ RAWS. The following actions were taken:

? The wind speed sensor was replaced.

? The wind direction sensor was replaced.

? The solar radiation sensor was replaced.

? The relative humidity/air temperature sensor was replaced.

? The fuel temperature sensor was replaced.

? The fuel moisture/fuel temperature sensor was replaced.

? The barometric pressure sensor was replaced.

? The Data Collection Platform (DCP) was upgraded to an H555 system.

? The soil moisture/soil temperature sensor was replaced.

? The battery in the DCP was replaced.

? The tipping bucket was replaced and reset to 00.02 inches from an accumulated reading of _________ inches.

? Other pertinent information: In addition to the above maintenance,

* In addition to the above maintenance, this station was inspected for structural strength, mechanical wear and tear, proper systems alignment, and operational accuracy.

Appendix E. Weather station maintenance schedule and equipment

The following equipment is kept in a weather station toolbox:

- Magnetic compass
- Volt/ohm meter
- Allen wrench set
- Level (12" - 24")
- Needle-nose pliers
- Straight-bit screwdrivers (small, medium, and large)
- Phillips screwdrivers (small and medium)
- Pocketknife
- Wire strippers
- Open-ended wrenches 3/8", 7/16", 1/2", and 9/16"
- Socket wrench and 7/16" deep well socket
- Electrical tape
- Measuring tape
- Degree meter
- Silicone
- Garden spade
- Nylon wire ties
- Scissors
- Spare cap for pyranometer
- Toothbrush
- Felt-tipped marking pen
- 12 cc syringe
- Calculator

The following equipment is needed, but it is not carried in the toolbox:

- Silicone spray
- Lithium grease
- Hacksaw
- 12" pipe wrench
- Water
- Paper towels
- CR10 Operator’s Manual with prompt sheet
- CR10 keypad
- SC12 ribbon cable
- 6' stepladder
- Sledgehammer (small)
- Shovel
- Scouring brush
- Station log/pen

Sensor maintenance will be performed at regular intervals, depending on the desired accuracy and the conditions of use. A suggested maintenance schedule is outlined below:

Six months

1. Check the pyranometer for level and contamination.
2. Check the rain gauge funnel for debris and level.
3. Do a visual/audio inspection of the anemometer at low wind speeds.
4. Clean the radiation shield.
5. Clean the temperature/humidity sensor.
6. Replace the dessicants inside the enclosure.

One year

1. Calibrate the rain gauge.
2. Calibrate the HMP35C probe.
3. Replace dessicants (Model #DSC SO-2) in the Sonic Ranging Sensor (WICR).
4. Replace the fuel moisture probe.

Two years

1. Calibrate the pyranometer.
2. Replace the anemometer bearings.

Three years

1. Replace the wind vane potentiometer.

Five years

1. Replace sensor cables as needed.
2. Calibrate the datalogger.

Five to Ten years

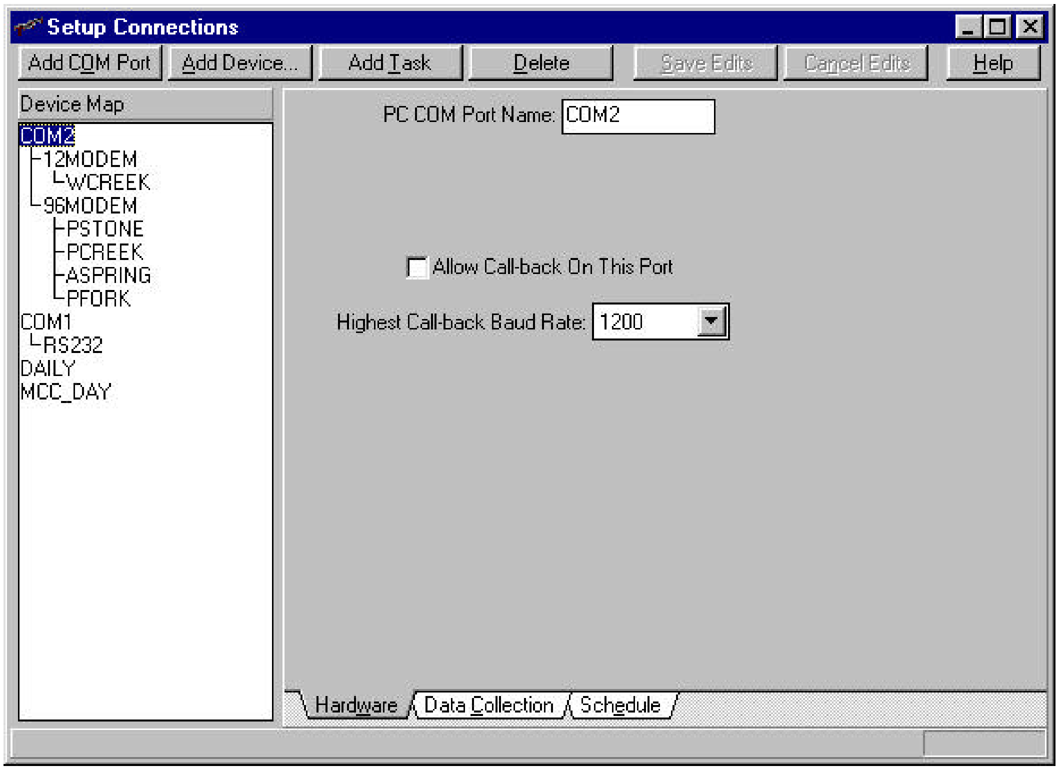
1. Replace soil temperature probe.
2. Replace soil moisture probe.

General maintenance

1. Clean the glass on the solar panel to improve efficiency.
2. Check sensor leads and cables for cracking, deterioration, proper routing, and strain relief.
3. Check the tripod for structural damage and for proper alignment and to ensure it is level/plumb.

Appendix F. Setup configuration for Wilson's Creek National Battlefield And Pipestone National Monument

Figure F-1. Setup configuration for Wilson's Creek National Battlefield and Pipestone National Monument.



Appendix G. EDLOG program for Wilson's Creek National Battlefield

```
;{CR10X}
;
*Table 1 Program
  01: 60        Execution Interval (seconds)

1:  Batt Voltage (P10)
 1: 1        Loc [ Batt_Volt ]

2:  Temp (107) (P11)
 1: 1        Reps
 2: 2        SE Channel
 3: 1        Excite all reps w/Exchan 1
 4: 2        Loc [ TempC     ]
 5: 1.0      Mult
 6: 0        Offset

3:  Excite-Delay (SE) (P4)
 1: 1        Reps
 2: 5        2500 mV Slow Range
 3: 3        SE Channel
 4: 2        Excite all reps w/Exchan 2
 5: 15       Delay (units 0.01 sec)
 6: 2500     mV Excitation
 7: 3        Loc [ RH        ]
 8: 0.001    Mult
 9: 0        Offset

;If RH>1, set it to 1.

4:  If (X<=>F) (P89)
 1: 3        X Loc [ RH        ]
 2: 3        >=
 3: 1        F
 4: 30       Then Do

5:  Z=F (P30)
 1: 1        F
 2: 0        Exponent of 10
 3: 3        Z Loc [ RH        ]

6:  End (P95)

7:  Saturation Vapor Pressure (P56)
 1: 2        Temperature Loc [ TempC     ]
 2: 4        Loc [ VPkPa     ]

8:  Z=X*Y (P36)
 1: 4        X Loc [ VPkPa     ]
```

```
 2: 3       Y Loc [ RH       ]
 3: 4       Z Loc [ VPkPa    ]

9:  Z=X*F (P37)
 1: 3       X Loc [ RH       ]
 2: 100     F
 3: 3       Z Loc [ RH       ]

10:  Pulse (P3)
 1: 1       Reps
 2: 1       Pulse Input Channel
 3: 21      Low Level AC, Output Hz
 4: 5       Loc [ WSmps    ]
 5: 0.098   Mult
 6: 0       Offset

11:  Excite-Delay (SE) (P4)
 1: 1       Reps
 2: 5       2500 mV Slow Range
 3: 4       SE Channel
 4: 2       Excite all reps w/Exchan 2
 5: 2       Delay (units 0.01 sec)
 6: 2500    mV Excitation
 7: 6       Loc [ WDirdeg  ]
 8: 0.142   Mult
 9: 0       Offset

12:  Volt (Diff) (P2)
 1: 1       Reps
 2: 23      25 mV 60 Hz Rejection Range
 3: 3       DIFF Channel
 4: 7       Loc [ SlrWpsm  ]
 5: 200     Mult
 6: 0       Offset

;If Solar Radiation is less than zero, set it to zero.

13:  IF (X<=>F) (P89)
 1: 7       X Loc [ SlrWpsm  ]
 2: 4       <
 3: 0       F
 4: 30      Then Do

14:  Z=F (P30)
 1: 0       F
 2: 0       Exponent of 10
 3: 7       Z Loc [ SlrWpsm  ]
```

15: End (P95)

16: Z=X*F (P37)
 1: 7   X Loc [SlrWpsm   ]
 2: .00006   F
 3: 37   Z Loc [SlrMJpsm]

;Rainfall Amount in mm.

17: Pulse (P3)
 1: 1   Reps
 2: 2   Pulse Input Channel
 3: 2   Switch Closure, All Counts
 4: 8   Loc [Rainmm   ]
 5: 0.254   Mult
 6: 0   Offset

18: Do (P86)
 1: 43   Set Port 3 High

19: Do (P86)
 1: 74   Pulse Port 4

20: Excitation with Delay (P22)
 1: 1   Ex Channel
 2: 0   Delay W/Ex (units = 0.01 sec)
 3: 5   Delay After Ex (units = 0.01 sec)
 4: 0   mV Excitation

21: Temp (107) (P11)
 1: 1   Reps
 2: 12   SE Channel
 3: 3   Excite all reps w/Exchan 3
 4: 9   Loc [STempMH   ]
 5: 1   Mult
 6: 0   Offset

22: Do (P86)
 1: 74   Pulse Port 4

23: Excitation with Delay (P22)
 1: 1   Ex Channel
 2: 0   Delay W/Ex (units = 0.01 sec)
 3: 5   Delay After Ex (units = 0.01 sec)
 4: 0   mV Excitation

24: Temp (107) (P11)
 1: 1   Reps

2: 12 SE Channel
3: 3 Excite all reps w/Exchan 3
4: 10 Loc [STempDL]
5: 1 Mult
6: 0 Offset

25: Do (P86)
1: 74 Pulse Port 4

26: Excitation with Delay (P22)
1: 1 Ex Channel
2: 0 Delay W/Ex (units = 0.01 sec)
3: 5 Delay After Ex (units = 0.01 sec)
4: 0 mV Excitation

27: Temp (107) (P11)
1: 1 Reps
2: 12 SE Channel
3: 3 Excite all reps w/Exchan 3
4: 11 Loc [STempWSG]
5: 1 Mult
6: 0 Offset

28: Do (P86)
1: 74 Pulse Port 4

29: Excitation with Delay (P22)
1: 1 Ex Channel
2: 0 Delay W/Ex (units = 0.01 sec)
3: 5 Delay After Ex (units = 0.01 sec)
4: 0 mV Excitation

30: Temp (107) (P11)
1: 1 Reps
2: 12 SE Channel
3: 3 Excite all reps w/Exchan 3
4: 12 Loc [STempRH]
5: 1 Mult
6: 0 Offset

31: Do (P86)
1: 46 Set Port 6 High

32: Beginning of Loop (P87)
1: 0 Delay
2: 4 Loop Count

33: Do (P86)
 1: 74   Pulse Port 4

34: Excitation with Delay (P22)
 1: 1   Ex Channel
 2: 0   Delay W/Ex (units = 0.01 sec)
 3: 2   Delay After Ex (units = 0.01 sec)
 4: 0   mV Excitation

35: Step Loop Index (P90)
 1: 1   Step

36: Period Average (SE) (P27)
 1: 1   Reps
 2: 4   2 V Peak to Peak/150 kHz Max. Freq.
 3: 12   SE Channel
 4: 10   No. of Cycles
 5: 5   Timeout (units = 0.01 seconds)
 6: 13   -- Loc [Moisture]
 7: 0.001   Mult
 8: 0   Offset

37: End (P95)

38: Do (P86)
 1: 53   Set Port 3 Low

39: Do (P86)
 1: 56   Set Port 6 Low

40: Polynomial (P55)
 1: 4   Reps
 2: 13   X Loc [Moisture]
 3: 17   F(X) Loc [SM_RH   ]
 4: -0.187   C0
 5: 0.037   C1
 6: 0.335   C2
 7: 0   C3
 8: 0   C4
 9: 0   C5

41: Z=X+F (P34)
 1: 2   X Loc [TempC   ]
 2: 273.15   F
 3: 21   Z Loc [TempK   ]

42: SDI-12 Recorder (OS10 1.1) (P105)
 1: 0   SDI-12 Address

```
 2: 0        Start Measurement (aM0!)
 3: 2        Port
 4: 22       Loc [ Distance  ]
 5: -1       Mult
 6: 0        Offset

43:  Z=F (P30)
 1: 273.15   F
 2: 0        Exponent of 10
 3: 23       Z Loc [ RefTemp   ]

44:  Z=X/Y (P38)
 1: 21       X Loc [ TempK     ]
 2: 23       Y Loc [ RefTemp   ]
 3: 24       Z Loc [ Mult      ]

45:  Z=SQRT(X) (P39)
 1: 24       X Loc [ Mult      ]
 2: 24       Z Loc [ Mult      ]

46:  Z=X*Y (P36)
 1: 22       X Loc [ Distance  ]
 2: 24       Y Loc [ Mult      ]
 3: 22       Z Loc [ Distance  ]

47:  Z=X+F (P34)
 1: 22       X Loc [ Distance  ]
 2: 0.76     F
 3: 25       Z Loc [ SnowDepth ]

;If SnowDepth<0, set it to 0.

48:  If (X<=>F) (P89)
 1: 25       X Loc [ SnowDepth ]
 2: 4        <
 3: 0        F
 4: 30       Then Do

49:  Z=F (P30)
 1: 0        F
 2: 0        Exponent of 10
 3: 25       Z Loc [ SnowDepth ]

50:  End (P95)

;Measure 439C Fuel Temperature

51:  Excite-Delay (SE) (P4)
```

1: 1 Reps
2: 5 2500 mV Slow Range
3: 11 SE Channel
4: 3 Excite all reps w/Exchan 3
5: 1 Delay (units 0.01 sec)
6: 2500 mV Excitation
7: 27 Loc [Fuel_Temp]
8: 0.0004 Mult
9: 0 Offset

;Go to Subroutine 1 to compute Fuel Temperature

52: Do (P86)
1: 1 Call Subroutine 1

;Delay 2 sec before measurement

53: Excitation with Delay (P22)
1: 3 Ex Channel
2: 0 Delay W/Ex (units = 0.01 sec)
3: 200 Delay After Ex (units = 0.01 sec)
4: 0 mV Excitation

;Measure Fuem Moisture Voltage signal and convert it from mV
;to V, hence the multiplier is 0.001

54: Volts (SE) (P1)
1: 1 Reps
2: 5 2500 mV Slow Range
3: 7 SE Channel
4: 28 Loc [FM_mV]
5: 0.001 Mult
6: 0 Offset

;Go to Subroutine 2 to compute Fuel Moisture from the Voltage Signal

55: Do (P86)
1: 2 Call Subroutine 2

56: If time is (P92)
1: 0 Minutes (Seconds --) into a
2: 60 Interval (same units as above)
3: 10 Set Output Flag High

57: Set Active Storage Area (P80)
1: 1 Final Storage Area 1
2: 111 Array ID

58: Real Time (P77)
 1: 220   Day,Hour/Minute (midnight = 2400)

59: Average (P71)
 1: 1   Reps
 2: 2   Loc [TempC   ]

60: Sample (P70)
 1: 1   Reps
 2: 3   Loc [RH   ]

61: Average (P71)
 1: 1   Reps
 2: 4   Loc [VPkPa   ]

62: Average (P71)
 1: 1   Reps
 2: 7   Loc [SlrWpsm   ]

63: Wind Vector (P69)
 1: 1   Reps
 2: 0   Samples per Sub-Interval
 3: 0   S, é1, & å(é1) Polar
 4: 5   Wind Speed/East Loc [WSmps   ]
 5: 6   Wind Direction/North Loc [WDirdeg   ]

64: Totalize (P72)
 1: 1   Reps
 2: 8   Loc [Rainmm   ]

65: Sample (P70)
 1: 4   Reps
 2: 17   Loc [SM_RH   ]

66: Average (P71)
 1: 1   Reps
 2: 9   Loc [STempMH   ]

67: Average (P71)
 1: 1   Reps
 2: 11   Loc [STempWSG]

68: Average (P71)
 1: 1   Reps
 2: 12   Loc [STempRH   ]

69: Sample (P70)
 1: 1   Reps

2: 25 Loc [SnowDepth]

70: Average (P71)
1: 1 Reps
2: 10 Loc [STempDL]

71: Average (P71)
1: 1 Reps
2: 27 Loc [Fuel_Temp]

72: Average (P71)
1: 1 Reps
2: 29 Loc [Fuel_Mois]

73: If time is (P92)
1: 0 Minutes (Seconds --) into a
2: 1440 Interval (same units as above)
3: 10 Set Output Flag High

74: Set Active Storage Area (P80)
1: 1 Final Storage Area 1
2: 222 Array ID

75: Real Time (P77)
1: 1220 Year,Day,Hour/Minute (midnight = 2400)

76: Average (P71)
1: 1 Reps
2: 2 Loc [TempC]

77: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 2 Loc [TempC]

78: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 2 Loc [TempC]

79: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 3 Loc [RH]

80: Minimize (P74)
1: 1 Reps
2: 0 Value Only

3: 3 Loc [RH]

81: Average (P71)
1: 1 Reps
2: 4 Loc [VPkPa]

82: Totalize (P72)
1: 1 Reps
2: 37 Loc [SlrMJpsm]

83: Wind Vector (P69)
1: 1 Reps
2: 0 Samples per Sub-Interval
3: 0 S, é1, & å(é1) Polar
4: 5 Wind Speed/East Loc [WSmps]
5: 6 Wind Direction/North Loc [WDirdeg]

84: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 5 Loc [WSmps]

85: Totalize (P72)
1: 1 Reps
2: 8 Loc [Rainmm]

86: Average (P71)
1: 4 Reps
2: 17 Loc [SM_RH]

87: Average (P71)
1: 1 Reps
2: 9 Loc [STempMH]

88: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 9 Loc [STempMH]

89: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 9 Loc [STempMH]

90: Average (P71)
1: 1 Reps
2: 11 Loc [STempWSG]

91: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 11 Loc [STempWSG]

92: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 11 Loc [STempWSG]

93: Average (P71)
1: 1 Reps
2: 12 Loc [STempRH]

94: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 12 Loc [STempRH]

95: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 12 Loc [STempRH]

96: Sample (P70)
1: 1 Reps
2: 1 Loc [Batt_Volt]

97: Average (P71)
1: 1 Reps
2: 10 Loc [STempDL]

98: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 10 Loc [STempDL]

99: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 10 Loc [STempDL]

100: Average (P71)
1: 1 Reps
2: 27 Loc [Fuel_Temp]

```
101:  Maximize (P73)
 1: 1        Reps
 2: 0        Value Only
 3: 27       Loc [ Fuel_Temp ]

102:  Minimize (P74)
 1: 1        Reps
 2: 0        Value Only
 3: 27       Loc [ Fuel_Temp ]

103:  Average (P71)
 1: 1        Reps
 2: 29       Loc [ Fuel_Mois ]

104:  Maximize (P73)
 1: 1        Reps
 2: 0        Value Only
 3: 29       Loc [ Fuel_Mois ]

105:  Minimize (P74)
 1: 1        Reps
 2: 0        Value Only
 3: 29       Loc [ Fuel_Mois ]

106:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 15       Interval (same units as above)
 3: 10       Set Output Flag High

107:  Set Active Storage Area (P80)
 1: 3        Input Storage Area
 2: 26       Loc [ RainTotal ]

108:  Totalize (P72)
 1: 1        Reps
 2: 8        Loc [ Rainmm    ]

109:  IF (X<=>F) (P89)
 1: 26       X Loc [ RainTotal ]
 2: 2        <>
 3: 0        F
 4: 30       Then Do

110:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 444      Array ID

111:  Real Time (P77)
```

```
 1: 220      Day,Hour/Minute (midnight = 2400)

112:  Sample (P70)
 1: 1        Reps
 2: 26       Loc [ RainTotal ]

113:  End (P95)

;Fire Weather Output with a 1pm Dump time.
;Fire Weather Day starts and ends at 1pm.
;Set Array ID 333 as Fire Weather Output.

114:  If time is (P92)
 1: 780      Minutes (Seconds --) into a
 2: 1440     Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

115:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 333      Array ID

116:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

117:  Maximum (P73)
 1: 1        Reps
 2: 00       Time Option
 3: 2        Loc [ TempC     ]

118:  Minimum (P74)
 1: 1        Reps
 2: 00       Time Option
 3: 2        Loc [ TempC     ]

119:  Maximum (P73)
 1: 1        Reps
 2: 00       Time Option
 3: 3        Loc [ RH        ]

120:  Minimum (P74)
 1: 1        Reps
 2: 00       Time Option
 3: 3        Loc [ RH        ]

121:  Totalize (P72)
 1: 1        Reps
 2: 8        Loc [ Rainmm    ]
```

```
122:  Maximum (P73)
 1: 1         Reps
 2: 00        Time Option
 3: 5         Loc [ WSmps     ]

;Turn off the cell phone at 6pm and back on at 7am.

123:  Time (P18)
 1: 1         Minutes into current day (maximum 1440)
 2: 0000      Mod/By
 3: 36        Loc [ Minutes   ]

;Turn it off before 7am.

124:  If (X<=>F) (P89)
 1: 36        X Loc [ Minutes   ]
 2: 4         <
 3: 420       F
 4: 55        Set Port 5 Low

;After 7am and before 5pm, turn it on.

125:  If (X<=>F) (P89)
 1: 36        X Loc [ Minutes   ]
 2: 3         >=
 3: 420       F
 4: 30        Then Do

126:  If (X<=>F) (P89)
 1: 36        X Loc [ Minutes   ]
 2: 4         <
 3: 1020      F
 4: 45        Set Port 5 High

127:  End (P95)

;After 5pm, turn it off.

128:  If (X<=>F) (P89)
 1: 36        X Loc [ Minutes   ]
 2: 3         >=
 3: 1020      F
 4: 55        Set Port 5 Low


*Table 2 Program
  02: 0.0000    Execution Interval (seconds)
```

*Table 3 Subroutines

```
1:  Beginning of Subroutine (P85)
 1: 1        Subroutine 1

;Bridge Transform in kohms

2:  BR Transform Rf[X/(1-X)] (P59)
 1: 1        Reps
 2: 27       Loc [ Fuel_Temp ]
 3: 1        Multiplier (Rf)

;Conver kohms to ohms

3:  Z=X*F (P37)
 1: 27       X Loc [ Fuel_Temp ]
 2: 1000     F
 3: 27       Z Loc [ Fuel_Temp ]

;Save thermister ohm value

4:  Z=X (P31)
 1: 27       X Loc [ Fuel_Temp ]
 2: 30       Z Loc [ FTohms    ]

;Computation of Fuel Temperature from Steinhart-Hart Eq.

;1/T=A+BlnR+C(lnR)^3
;where A=1.029x10^-3
;     B=2.393x10^-4
;     C=1.563x10^-7
;     R:Resistance in ohms
;     T:Temperature in C

5:  Z=LN(X) (P40)
 1: 27       X Loc [ Fuel_Temp ]
 2: 27       Z Loc [ Fuel_Temp ]

6:  Z=F (P30)
 1: 1.029    F
 2: -3       Exponent of 10
 3: 31       Z Loc [ A         ]

7:  Z=F (P30)
 1: 2.393    F
 2: -4       Exponent of 10
 3: 32       Z Loc [ B         ]
```

```
8:  Z=F (P30)
 1: 1.563    F
 2: -7       Exponent of 10
 3: 33       Z Loc [ C          ]

9:  Z=X*Y (P36)
 1: 27       X Loc [ Fuel_Temp ]
 2: 27       Y Loc [ Fuel_Temp ]
 3: 34       Z Loc [ scratch1  ]

10:  Z=X*Y (P36)
 1: 27       X Loc [ Fuel_Temp ]
 2: 34       Y Loc [ scratch1  ]
 3: 34       Z Loc [ scratch1  ]

11:  Z=X*Y (P36)
 1: 34       X Loc [ scratch1  ]
 2: 33       Y Loc [ C         ]
 3: 34       Z Loc [ scratch1  ]

12:  Z=X*Y (P36)
 1: 27       X Loc [ Fuel_Temp ]
 2: 32       Y Loc [ B         ]
 3: 35       Z Loc [ scratch2  ]

13:  Z=X+Y (P33)
 1: 34       X Loc [ scratch1  ]
 2: 35       Y Loc [ scratch2  ]
 3: 27       Z Loc [ Fuel_Temp ]

14:  Z=X+Y (P33)
 1: 31       X Loc [ A         ]
 2: 27       Y Loc [ Fuel_Temp ]
 3: 27       Z Loc [ Fuel_Temp ]

15:  Z=1/X (P42)
 1: 27       X Loc [ Fuel_Temp ]
 2: 27       Z Loc [ Fuel_Temp ]

16:  Z=X+F (P34)
 1: 27       X Loc [ Fuel_Temp ]
 2: -273.15  F
 3: 27       Z Loc [ Fuel_Temp ]

;End Subroutine 1

17:  End (P95)
```

```
;Begin Subroutine 2 for Fuel Moisture Measurement

18:  Beginning of Subroutine (P85)
 1: 2        Subroutine 2

;If the FM signal is 0.24 and less, set it to 0.24.
;Therefore the min FM is 0.95%

19:  IF (X<=>F) (P89)
 1: 28       X Loc [ FM_mV     ]
 2: 4        <
 3: 0.24     F
 4: 30       Then Do

20:  Z=F (P30)
 1: 0.24     F
 2: 0        Exponent of 10
 3: 28       Z Loc [ FM_mV     ]

21:  Z=F (P30)
 1: 0.95     F
 2: 0        Exponent of 10
 3: 29       Z Loc [ Fuel_Mois ]

22:  End (P95)

;If the FM signal is less than .54 use the polynomial
;to compute FM in %

23:  IF (X<=>F) (P89)
 1: 28       X Loc [ FM_mV     ]
 2: 4        <
 3: 0.54     F
 4: 30       Then Do

24:  Polynomial (P55)
 1: 1        Reps
 2: 28       X Loc [ FM_mV     ]
 3: 29       F(X) Loc [ Fuel_Mois ]
 4: -41.415  C0
 5: 254.23   C1
 6: -365.96  C2
 7: 171.51   C3
 8: 0        C4
 9: 0        C5

;Else use Mutiplier and offset
```

```
25:  Else (P94)

26:  Z=X*F (P37)
 1: 28       X Loc [ FM_mV     ]
 2: 15.772   F
 3: 29       Z Loc [ Fuel_Mois ]

27:  Z=X+F (P34)
 1: 29       X Loc [ Fuel_Mois ]
 2: 7.683    F
 3: 29       Z Loc [ Fuel_Mois ]

;End Else

28:  End (P95)

;End Subroutine 2

29:  End (P95)


End Program
```

-Input Locations-
1 Batt_Volt
2 TempC
3 RH
4 VPkPa
5 WSmps
6 WDirdeg
7 SlrWpsm
8 Rainmm
9 STempMH
10 STempDL
11 STempWSG
12 STempRH
13 Moisture
14 __________
15 __________
16 __________
17 SM_RH
18 SM_WSG
19 SM_DL
20 SM_MH
21 TempK
22 Distance
23 RefTemp
24 Mult
25 SnowDepth
26 RainTotal
27 Fuel_Temp
28 FM_mV
29 Fuel_Mois
30 FTohms
31 A
32 B
33 C
34 scratch1
35 scratch2
36 Minutes
37 SlrMJpsm

Appendix H. EDLOG program for Pipestone National Monument

```
;{CR10X}
;
*Table 1 Program
  01: 60        Execution Interval (seconds)

;Measure Battery Voltage in Volts.

1:  Batt Voltage (P10)
 1: 1         Loc [ Batt_Volt ]

;CS500 Measurements.

;Temperature in deg_C.

2:  Volts (SE) (P1)
 1: 1         Reps
 2: 25        2500 mV 60 Hz Rejection Range
 3: 2         SE Channel
 4: 2         Loc [ Temp_C    ]
 5: 0.1       Mult
 6: -40       Offset

;Relative Humidity.

3:  Volts (SE) (P1)
 1: 1         Reps
 2: 25        2500 mV 60 Hz Rejection Range
 3: 3         SE Channel
 4: 3         Loc [ RH        ]
 5: 0.001     Mult
 6: 0         Offset

;If RH>1, Set it to 1.

4:  IF (X<=>F) (P89)
 1: 3         X Loc [ RH        ]
 2: 3         >=
 3: 1         F
 4: 30        Then Do

5:  Z=F (P30)
 1: 1         F
 2: 0         Exponent of 10
 3: 3         Z Loc [ RH        ]

6:  End (P95)

;Saturation Vapor Pressure.
```

7: Saturation Vapor Pressure (P56)
 1: 2   Temperature Loc [Temp_C   ]
 2: 4   Loc [VP_kPa   ]

;Actual Vapor Pressure=Sat.VP*RH.

8: Z=X*Y (P36)
 1: 4   X Loc [VP_kPa   ]
 2: 3   Y Loc [RH   ]
 3: 4   Z Loc [VP_kPa   ]

;RH in %.

9: Z=X*F (P37)
 1: 3   X Loc [RH   ]
 2: 100   F
 3: 3   Z Loc [RH   ]

;Win Speed in m/s.

10: Pulse (P3)
 1: 1   Reps
 2: 1   Pulse Channel 1
 3: 21   Low Level AC, Output Hz
 4: 5   Loc [WS_mps   ]
 5: 0.098   Mult
 6: 0   Offset

;Wind Direction.

11: Excite-Delay (SE) (P4)
 1: 1   Reps
 2: 5   2500 mV Slow Range
 3: 4   SE Channel
 4: 2   Excite all reps w/Exchan 2
 5: 2   Delay (units 0.01 sec)
 6: 2500   mV Excitation
 7: 6   Loc [WD_deg   ]
 8: 0.142   Mult
 9: 0   Offset

;Solar Radiation.

12: Volt (Diff) (P2)
 1: 1   Reps
 2: 23   25 mV 60 Hz Rejection Range
 3: 3   DIFF Channel

```
 4: 7        Loc [ SR_Wpsm   ]
 5: 200      Mult
 6: 0        Offset

;If SR<0, Set it to 0.

13:  IF (X<=>F) (P89)
 1: 7        X Loc [ SR_Wpsm   ]
 2: 4        <
 3: 0        F
 4: 30       Then Do

14:  Z=F (P30)
 1: 0        F
 2: 0        Exponent of 10
 3: 7        Z Loc [ SR_Wpsm   ]

15:  End (P95)

16:  Z=X*F (P37)
 1: 7        X Loc [ SR_Wpsm   ]
 2: .00006   F
 3: 20       Z Loc [ SR_MJpsm  ]

;Rainfall in mm.

17:  Pulse (P3)
 1: 1        Reps
 2: 2        Pulse Channel 2
 3: 2        Switch Closure, All Counts
 4: 8        Loc [ R_mm      ]
 5: 0.254    Mult
 6: 0        Offset

;Soil Temperature at 100'.

18:  Temp (107) (P11)
 1: 1        Reps
 2: 1        SE Channel
 3: 3        Excite all reps w/E3
 4: 9        Loc [ ST100_C   ]
 5: 1.0      Mult
 6: 0        Offset

;Soil Temperature at 200'.

19:  Temp (107) (P11)
 1: 1        Reps
```

```
 2: 12       SE Channel
 3: 3        Excite all reps w/E3
 4: 10       Loc [ ST200_C   ]
 5: 1.0      Mult
 6: 0        Offset

;Soil Temperature at 300'.

20:  Temp (107) (P11)
 1: 1        Reps
 2: 9        SE Channel
 3: 2        Excite all reps w/E2
 4: 11       Loc [ ST300_C   ]
 5: 1.0      Mult
 6: 0        Offset

;Fuel Moisture.
;Since it takes 2 min and 20 sec to make a Fuel Moisture Measurement,
;Turn on the Control Port 3 min prior to measurement and turn it off.

21:  If time is (P92)
 1: 57       Minutes (Seconds --) into a
 2: 60       Interval (same units as above)
 3: 41       Set Port 1 High

22:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 60       Interval (same units as above)
 3: 30       Then Do

23:  Volts (SE) (P1)
 1: 1        Reps
 2: 5        2500 mV Slow Range
 3: 11       SE Channel
 4: 12       Loc [ FM        ]
 5: 0.001    Mult
 6: 0.5      Offset

24:  Z=X*F (P37)
 1: 12       X Loc [ FM        ]
 2: 10       F
 3: 12       Z Loc [ FM        ]

25:  Do (P86)
 1: 51       Set Port 1 Low

;Soil Moisture Measurements at 100',200' and 300 respectively.
;Turn on the port only once an hour prior to measurement.
```

;Sensor:CS615 Water Content Reflectometer.

26: Do (P86)
 1: 42 Set Port 2 High

27: Period Average (SE) (P27)
 1: 1 Reps
 2: 4 2 V Peak to Peak/150 kHz Max. Freq.
 3: 7 SE Channel
 4: 10 No. of Cycles
 5: 5 Timeout (units = 0.01 seconds)
 6: 13 Loc [P_100]
 7: 0.001 Mult
 8: 0 Offset

28: Do (P86)
 1: 52 Set Port 2 Low

29: Polynomial (P55)
 1: 1 Reps
 2: 13 X Loc [P_100]
 3: 14 F(X) Loc [SM_100]
 4: -0.22 C0
 5: 0.194 C1
 6: 0.145 C2
 7: 0 C3
 8: 0 C4
 9: 0 C5

30: Do (P86)
 1: 43 Set Port 3 High

31: Period Average (SE) (P27)
 1: 1 Reps
 2: 4 2 V Peak to Peak/150 kHz Max. Freq.
 3: 8 SE Channel
 4: 10 No. of Cycles
 5: 5 Timeout (units = 0.01 seconds)
 6: 15 Loc [P_200]
 7: 0.001 Mult
 8: 0 Offset

32: Do (P86)
 1: 53 Set Port 3 Low

33: Polynomial (P55)
 1: 1 Reps
 2: 15 X Loc [P_200]

3: 16 F(X) Loc [SM_200]
4: -0.22 C0
5: 0.194 C1
6: 0.145 C2
7: 0 C3
8: 0 C4
9: 0 C5

34: Do (P86)
1: 44 Set Port 4 High

35: Period Average (SE) (P27)
1: 1 Reps
2: 4 2 V Peak to Peak/150 kHz Max. Freq.
3: 10 SE Channel
4: 10 No. of Cycles
5: 5 Timeout (units = 0.01 seconds)
6: 17 Loc [P_300]
7: 0.001 Mult
8: 0 Offset

36: Do (P86)
1: 54 Set Port 4 Low

37: Polynomial (P55)
1: 1 Reps
2: 17 X Loc [P_300]
3: 18 F(X) Loc [SM_300]
4: -0.22 C0
5: 0.194 C1
6: 0.145 C2
7: 0 C3
8: 0 C4
9: 0 C5

38: End (P95)

;OUTPUT

;HOURLY (111) OUTPUT.

39: If time is (P92)
1: 0 Minutes (Seconds --) into a
2: 60 Interval (same units as above)
3: 10 Set Output Flag High (Flag 0)

40: Set Active Storage Area (P80)
1: 1 Final Storage Area 1

2: 111 Array ID

41: Real Time (P77)
1: 220 Day,Hour/Minute (midnight = 2400)

42: Average (P71)
1: 1 Reps
2: 2 Loc [Temp_C]

43: Sample (P70)
1: 1 Reps
2: 3 Loc [RH]

44: Average (P71)
1: 1 Reps
2: 4 Loc [VP_kPa]

45: Average (P71)
1: 1 Reps
2: 7 Loc [SR_Wpsm]

46: Wind Vector (P69)
1: 1 Reps
2: 0 Samples per Sub-Interval
3: 0 S, é1, & å(é1) Polar
4: 5 Wind Speed/East Loc [WS_mps]
5: 6 Wind Direction/North Loc [WD_deg]

47: Totalize (P72)
1: 1 Reps
2: 8 Loc [R_mm]

48: Average (P71)
1: 3 Reps
2: 9 Loc [ST100_C]

;Average Soil Moistures at 100,200 and 300'.

49: Sample (P70)
1: 6 Reps
2: 13 Loc [P_100]

;Sample Fuel Moisture.

50: Sample (P70)
1: 1 Reps
2: 12 Loc [FM]

;For WeatherPro to work, I added following information to ourly output.
;I added in the end of the hourly arrays to avoid changes in the hourly
;array structure of previously recorded parameters.

51: Real Time (P77)
 1: 1000 Year

52: Maximum (P73)
 1: 1 Reps
 2: 00 Time Option
 3: 5 Loc [WS_mps]

53: Maximum (P73)
 1: 1 Reps
 2: 00 Time Option
 3: 2 Loc [Temp_C]

54: Minimum (P74)
 1: 1 Reps
 2: 00 Time Option
 3: 2 Loc [Temp_C]

55: Maximum (P73)
 1: 1 Reps
 2: 00 Time Option
 3: 3 Loc [RH]

56: Minimum (P74)
 1: 1 Reps
 2: 00 Time Option
 3: 3 Loc [RH]

;DAILY (222) OUTPUT.

57: If time is (P92)
 1: 0 Minutes (Seconds --) into a
 2: 1440 Interval (same units as above)
 3: 10 Set Output Flag High (Flag 0)

58: Set Active Storage Area (P80)
 1: 1 Final Storage Area 1
 2: 222 Array ID

59: Real Time (P77)
 1: 1220 Year,Day,Hour/Minute (midnight = 2400)

60: Average (P71)
 1: 1 Reps

2: 2 Loc [Temp_C]

61: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 2 Loc [Temp_C]

62: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 2 Loc [Temp_C]

63: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 3 Loc [RH]

64: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 3 Loc [RH]

65: Average (P71)
1: 1 Reps
2: 4 Loc [VP_kPa]

66: Totalize (P72)
1: 1 Reps
2: 20 Loc [SR_MJpsm]

67: Wind Vector (P69)
1: 1 Reps
2: 0 Samples per Sub-Interval
3: 0 S, é1, & å(é1) Polar
4: 5 Wind Speed/East Loc [WS_mps]
5: 6 Wind Direction/North Loc [WD_deg]

68: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 5 Loc [WS_mps]

69: Totalize (P72)
1: 1 Reps
2: 8 Loc [R_mm]

70: Average (P71)
1: 1 Reps

2: 9 Loc [ST100_C]

71: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 9 Loc [ST100_C]

72: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 9 Loc [ST100_C]

73: Average (P71)
1: 1 Reps
2: 10 Loc [ST200_C]

74: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 10 Loc [ST200_C]

75: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 10 Loc [ST200_C]

76: Average (P71)
1: 1 Reps
2: 11 Loc [ST300_C]

77: Maximize (P73)
1: 1 Reps
2: 0 Value Only
3: 11 Loc [ST300_C]

78: Minimize (P74)
1: 1 Reps
2: 0 Value Only
3: 11 Loc [ST300_C]

79: Sample (P70)
1: 1 Reps
2: 1 Loc [Batt_Volt]

80: Average (P71)
1: 1 Reps
2: 14 Loc [SM_100]

```
81:  Average (P71)
 1: 1        Reps
 2: 18       Loc [ SM_300    ]


;15-MINUTE OUTPUT.

;Send a new variable, Total Rainfall, totaled every 15 minutes
;to input location 19, and report the total value on final staorege
;area 444, if there is a rainfall.

82:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 15       Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

83:  Set Active Storage Area (P80)
 1: 3        Input Storage Area
 2: 19       Loc [ RainTotal ]

84:  Totalize (P72)
 1: 1        Reps
 2: 8        Loc [ R_mm      ]

85:  IF (X<=>F) (P89)
 1: 19       X Loc [ RainTotal ]
 2: 2        <>
 3: 0        F
 4: 30       Then Do

86:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 444      Array ID

87:  Real Time (P77)
 1: 220      Day,Hour/Minute (midnight = 2400)

88:  Sample (P70)
 1: 1        Reps
 2: 19       Loc [ RainTotal ]

89:  End (P95)

;Fire Weather Output with a 1PM dump time.
;Fire Weather Day starts and ends at 1 PM.

90:  If time is (P92)
 1: 780      Minutes (Seconds --) into a
```

```
 2: 1440     Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

;Set array ID as 333 for the Fire Weather output.

91:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 333      Array ID

92:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

93:  Maximum (P73)
 1: 1        Reps
 2: 00       Time Option
 3: 2        Loc [ Temp_C    ]

94:  Minimum (P74)
 1: 1        Reps
 2: 00       Time Option
 3: 2        Loc [ Temp_C    ]

95:  Maximum (P73)
 1: 1        Reps
 2: 00       Time Option
 3: 3        Loc [ RH        ]

96:  Minimum (P74)
 1: 1        Reps
 2: 00       Time Option
 3: 3        Loc [ RH        ]

97:  Totalize (P72)
 1: 1        Reps
 2: 8        Loc [ R_mm      ]

98:  Sample (P70)
 1: 1        Reps
 2: 2        Loc [ Temp_C    ]

99:  Sample (P70)
 1: 1        Reps
 2: 3        Loc [ RH        ]

100:  Sample (P70)
 1: 2        Reps
 2: 5        Loc [ WS_mps    ]
```

```
101:  Sample (P70)
 1: 1        Reps
 2: 12       Loc [ FM        ]

102:  Maximum (P73)
 1: 1        Reps
 2: 00       Time Option
 3: 5        Loc [ WS_mps    ]


*Table 2 Program
  02: 0.0000    Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

-Input Locations-
1 Batt_Volt
2 Temp_C
3 RH
4 VP_kPa
5 WS_mps
6 WD_deg
7 SR_Wpsm
8 R_mm
9 ST100_C
10 ST200_C
11 ST300_C
12 FM
13 P_100
14 SM_100
15 P_200
16 SM_200
17 P_300
18 SM_300
19 RainTotal
20 SR_MJpsm

Appendix I. SPLIT, input and output configuration that generate hourly and daily reports for Wilson's Creek National Battlefield

Figure I-1. SPLIT program input configurations that generate hourly reports for the previous day for Wilson's Creek National Battlefield.

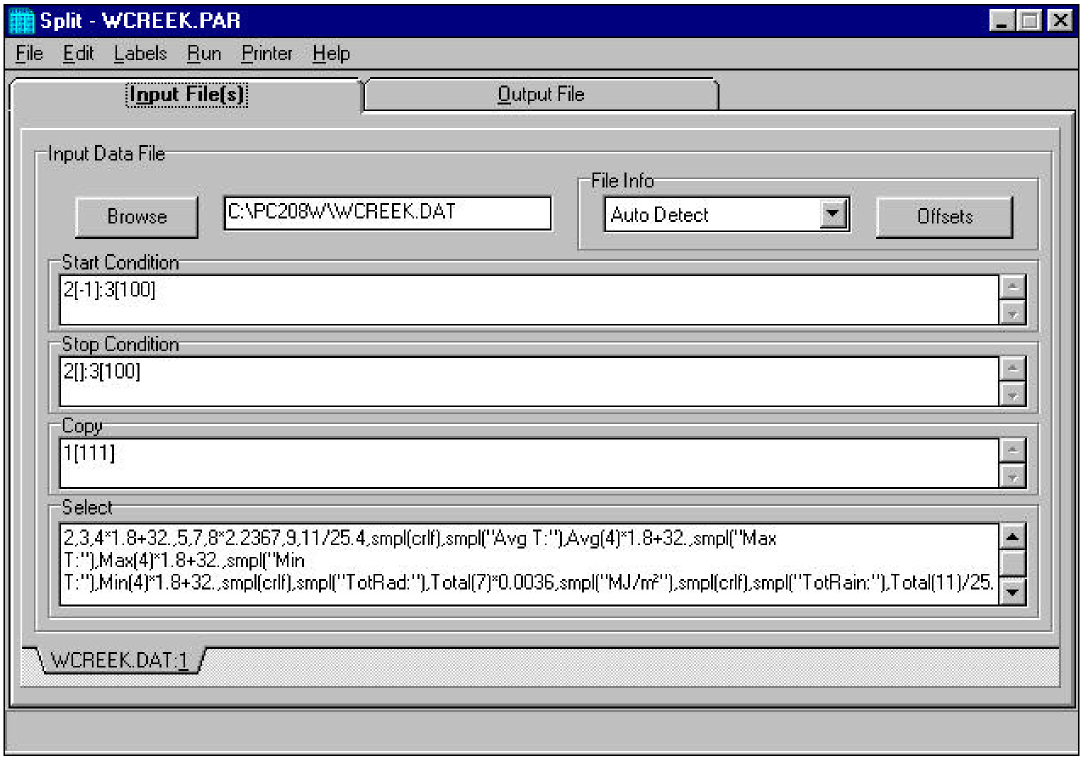


Figure I-2. Corresponding output configurations that generate hourly reports for the previous day for Wilson's Creek National Battlefield.

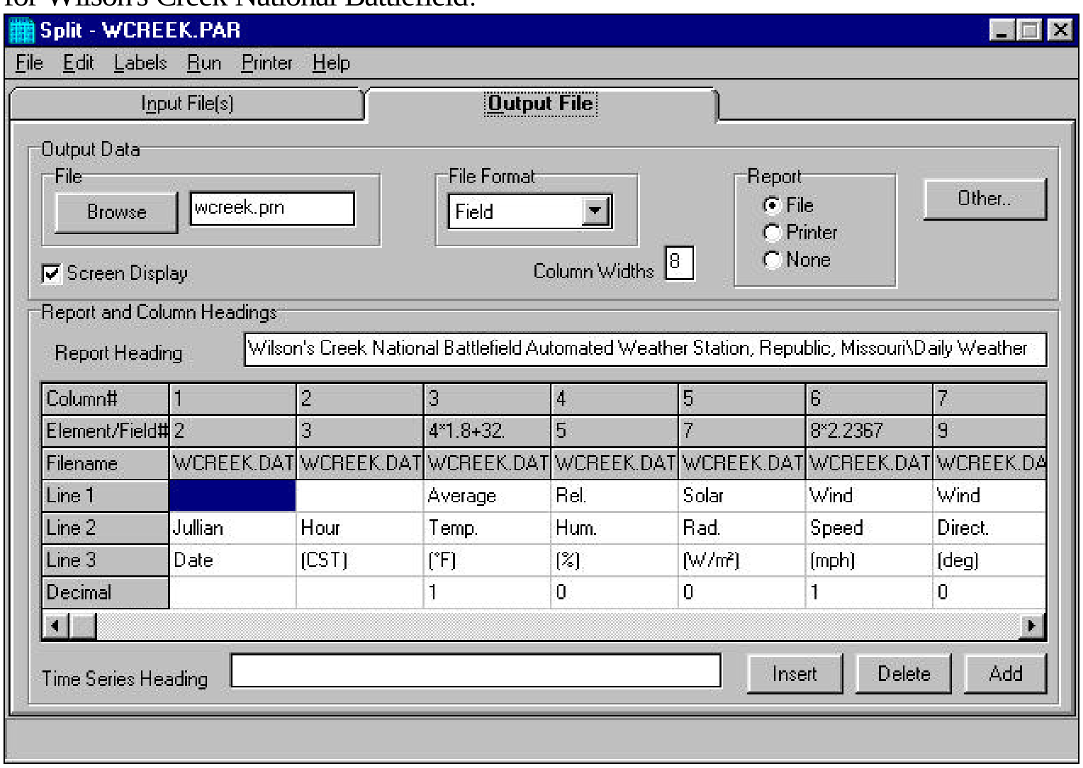


Figure I-3. SPLIT program input configurations that generate daily reports for Wilson's Creek National Battlefield.

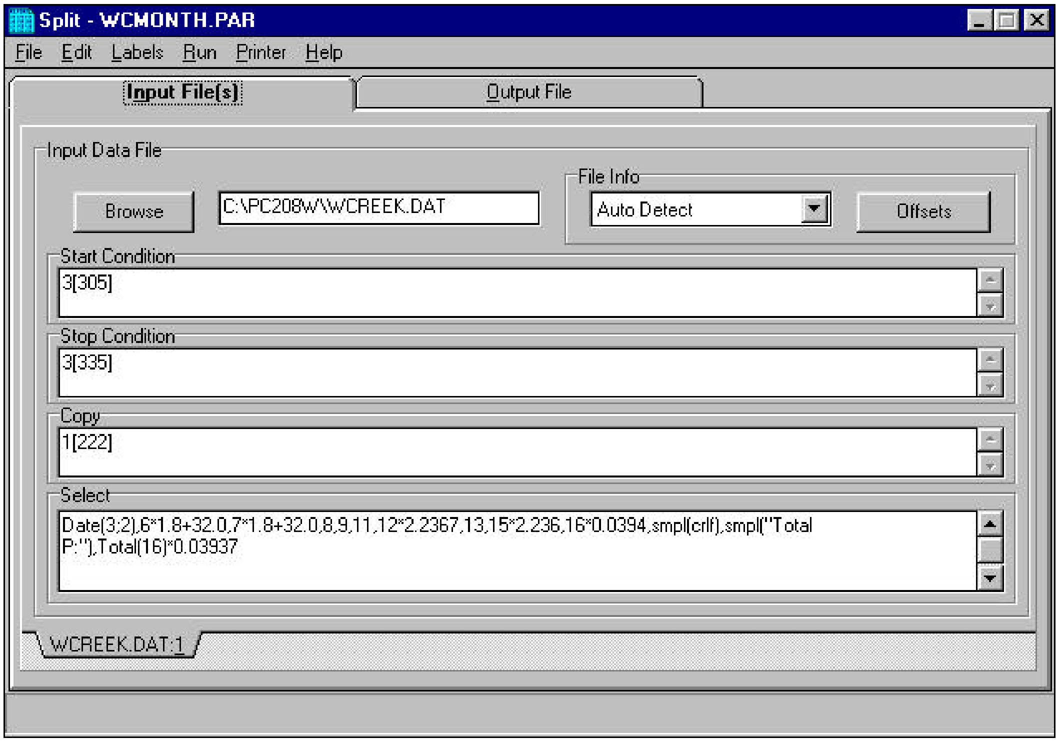
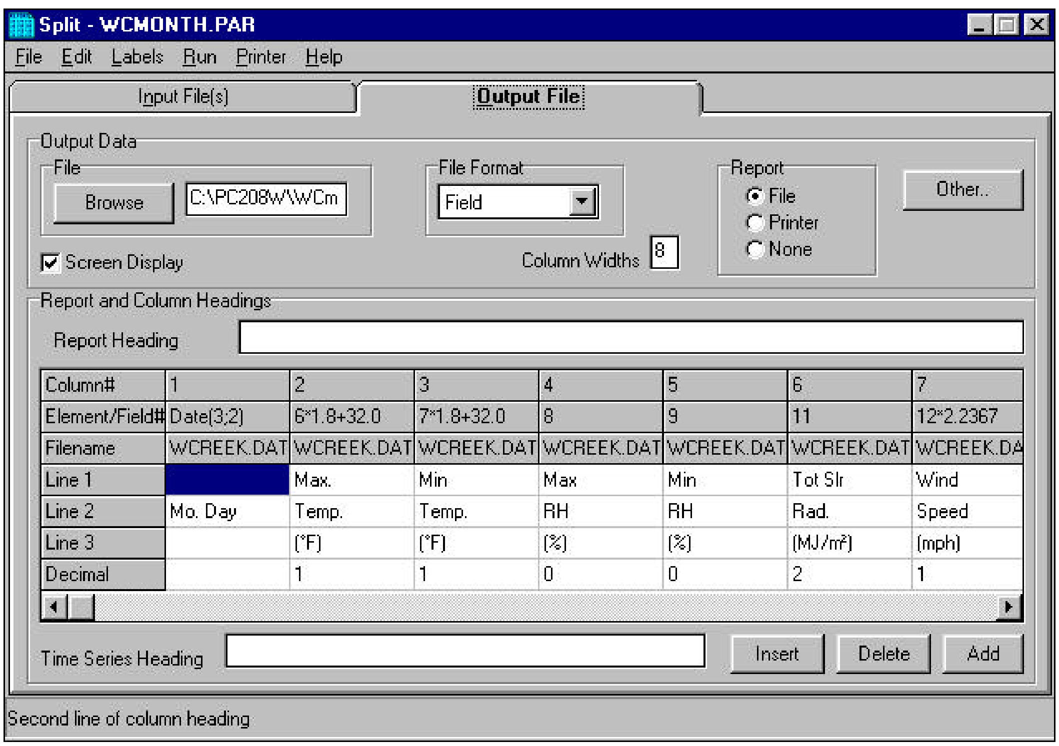


Figure I-4. Corresponding output configurations that generate daily reports for Wilson's Creek National Battlefield.



Appendix J. SPLIT, input and output configuration that generate hourly and daily reports for Pipestone National Monument

Figure J-1. SPLIT program, input configurations that generate hourly reports for the previous day for Pipestone National Monument.

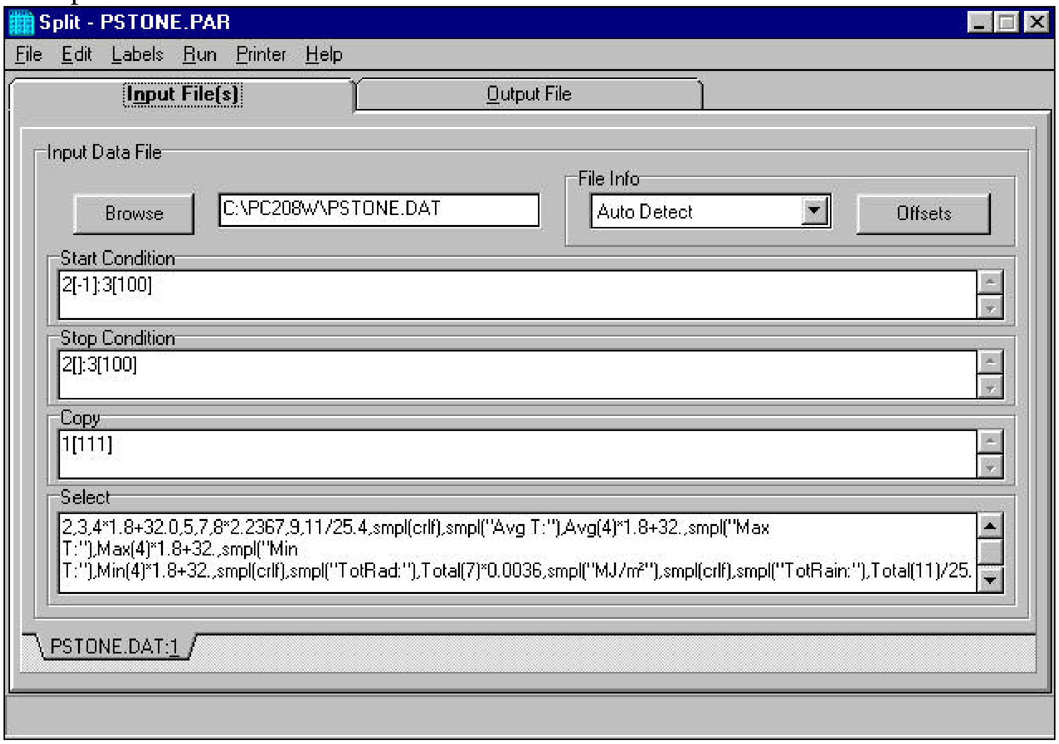


Figure J-2. Corresponding output configurations that generate hourly reports for the previous day for Pipestone National Monument.

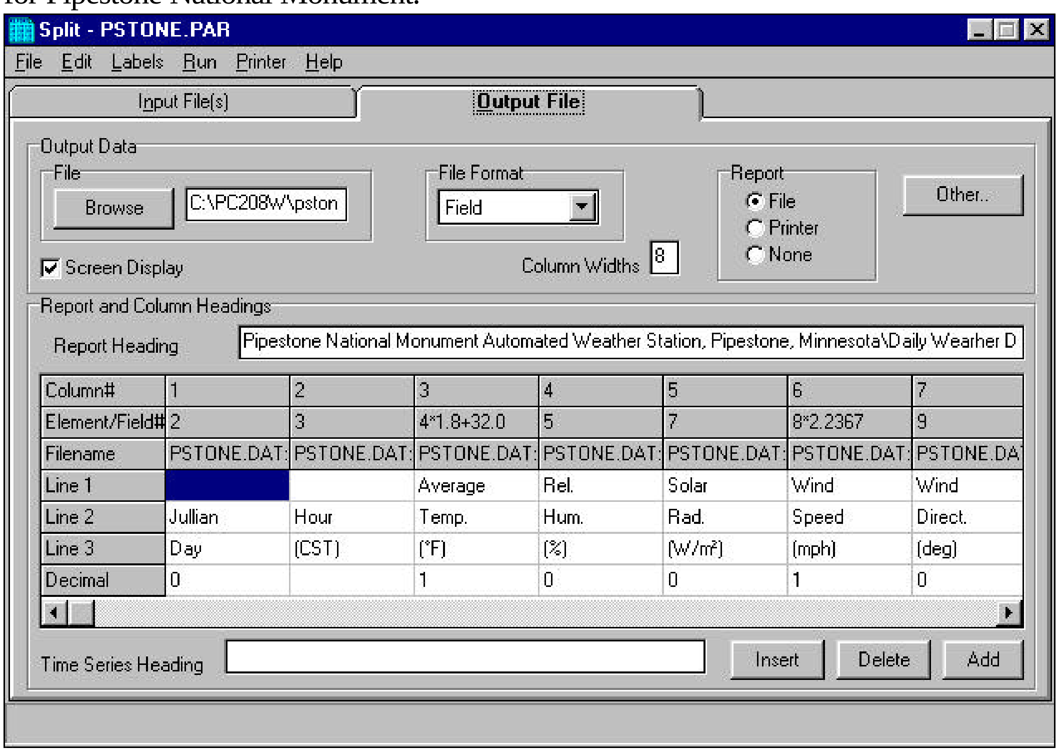


Figure J-3. SPLIT program, input configurations that generate daily reports for Pipestone National Monument.

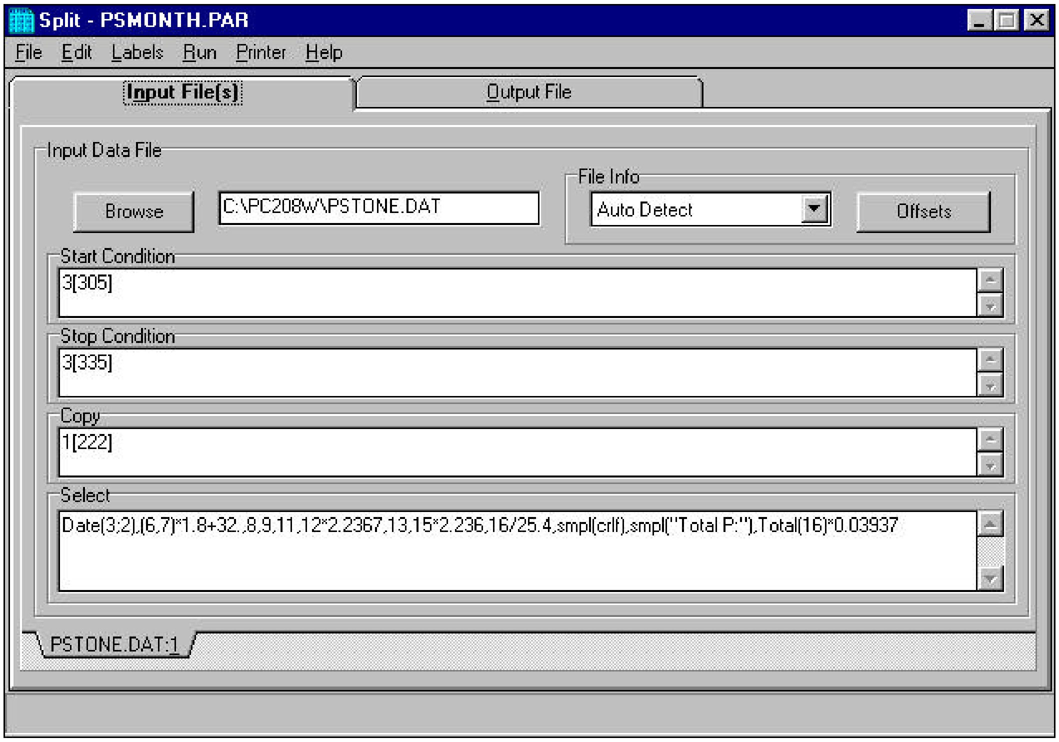
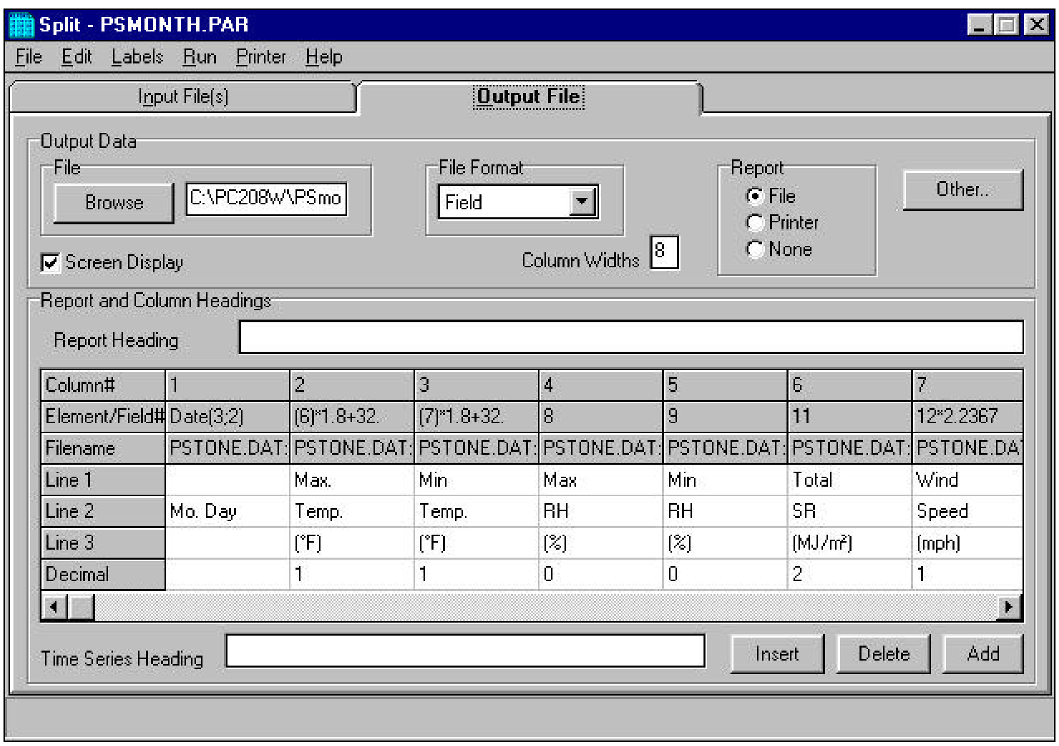


Figure J-4. Corresponding output configurations that generate daily reports for Pipestone National Monument.



Appendix K. Array structure for Wilson's Creek National Battlefield

Final Storage Label File for: WCREEK.CSI
Date: 1/29/1999
Time: 13:07:26

111 Output_Table 60.00 Min
1 111 L
2 Day_RTM L
3 Hour_Minute_RTM L
4 TempC_AVG L
5 RH L
6 VPkPa_AVG L
7 SlrWpsm_AVG L
8 WSmps_S_WVT L
9 WDirdeg_D1_WVT L
10 WDirdeg_SD1_WVT L
11 Rainmm_TOT L
12 SM_RH L
13 SM_WSG L
14 SM_DL L
15 SM_MH L
16 STempMH_AVG L
17 STempWSG_AVG L
18 STempRH_AVG L
19 SnowDepth L
20 STempDL_AVG L
21 Fuel_Temp_AVG L
22 Fuel_Mois_AVG L

222 Output_Table 1440.00 Min
1 222 L
2 Year_RTM L
3 Day_RTM L
4 Hour_Minute_RTM L
5 TempC_AVG L
6 TempC_MAX L
7 TempC_MIN L
8 RH_MAX L
9 RH_MIN L
10 VPkPa_AVG L
11 SlrMJpsm_TOT L
12 WSmps_S_WVT L
13 WDirdeg_D1_WVT L
14 WDirdeg_SD1_WVT L
15 WSmps_MAX L
16 Rainmm_TOT L
17 SM_RH_AVG L
18 SM_WSG_AVG L
19 SM_DL_AVG L
20 SM_MH_AVG L
21 STempMH_AVG L
22 STempMH_MAX L
23 STempMH_MIN L
24 STempWSG_AVG L
25 STempWSG_MAX L
26 STempWSG_MIN L
27 STempRH_AVG L
28 STempRH_MAX L
29 STempRH_MIN L
30 Batt_Volt L
31 STempDL_AVG L
32 STempDL_MAX L
33 STempDL_MIN L
34 Fuel_Temp_AVG L
35 Fuel_Temp_MAX L
36 Fuel_Temp_MIN L
37 Fuel_Mois_AVG L
38 Fuel_Mois_MAX L
39 Fuel_Mois_MIN L

26 Input_Storage 15.00 Min
1 Rainmm_TOT L
2 Day_RTM L
3 Hour_Minute_RTM L
4 RainTotal L

333 Output_Table 1440.00 Min
1 333 L
2 Year_RTM L
3 Day_RTM L
4 Hour_Minute_RTM L
5 TempC_MAX L
6 TempC_MIN L
7 RH_MAX L
8 RH_MIN L
9 Rainmm_TOT L
10 WSmps_MAX L

Estimated Total Final Storage Locations used per day 961.0

Appendix L. Array structure for Pipestone National Monument

Final Storage Label File for: PSTONE.CSI
Date: 3/10/2000
Time: 10:50:03

111 Output_Table 60.00 Min
1 111 L
2 Day_RTM L
3 Hour_Minute_RTM L
4 Temp_C_AVG L
5 RH L
6 VP_kPa_AVG L
7 SR_Wpsm_AVG L
8 WS_mps_S_WVT L
9 WD_deg_D1_WVT L
10 WD_deg_SD1_WVT L
11 R_mm_TOT L
12 ST100_C_AVG L
13 ST200_C_AVG L
14 ST300_C_AVG L
15 P_100 L
16 SM_100 L
17 P_200 L
18 SM_200 L
19 P_300 L
20 SM_300 L
21 FM L
22 Year_RTM L
23 WS_mps_MAX L
24 Temp_C_MAX L
25 Temp_C_MIN L
26 RH_MAX L
27 RH_MIN L

222 Output_Table 1440.00 Min
1 222 L
2 Year_RTM L
3 Day_RTM L
4 Hour_Minute_RTM L
5 Temp_C_AVG L
6 Temp_C_MAX L
7 Temp_C_MIN L
8 RH_MAX L
9 RH_MIN L
10 VP_kPa_AVG L
11 SR_MJpsm_TOT L
12 WS_mps_S_WVT L
13 WD_deg_D1_WVT L
14 WD_deg_SD1_WVT L
15 WS_mps_MAX L
16 R_mm_TOT L
17 ST100_C_AVG L
18 ST100_C_MAX L
19 ST100_C_MIN L
20 ST200_C_AVG L
21 ST200_C_MAX L
22 ST200_C_MIN L
23 ST300_C_AVG L
24 ST300_C_MAX L
25 ST300_C_MIN L
26 Batt_Volt L
27 SM_100_AVG L
28 SM_300_AVG L

19 Input_Storage 15.00 Min
1 R_mm_TOT L
2 Day_RTM L
3 Hour_Minute_RTM L
4 RainTotal L

333 Output_Table 1440.00 Min
1 333 L
2 Year_RTM L
3 Day_RTM L
4 Hour_Minute_RTM L
5 Temp_C_MAX L
6 Temp_C_MIN L
7 RH_MAX L
8 RH_MIN L
9 R_mm_TOT L
10 Temp_C L
11 RH L
12 WS_mps L
13 WD_deg L
14 FM L
15 WS_mps_MAX L

Estimated Total Final Storage Locations used per day 1075.0